Engineering Library

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VOL. CXLIV.—No. 3754] LONDON: FRIDAY EVENING, DECEMBER 23, 1927 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director-General,
India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for :—
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Forms of Tender obtainable from the above at a fee of 5s. per set, which will not be returned. 7282

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Further information may be obtained from the Harbour Engineer, Colombo. Offers should be addressed to the undersigned.
W. E. WAIT,
Chairman, Colombo Port Commission,
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Assistant Engineers (5)
REQUIRED by the GOVERNMENT of NIGERIA for the PUBLIC WORKS DEPARTMENT for two tours of not less than 12 nor more than 18 months' service in the first instance. Subject to satisfactory service, the officers appointed will be eligible at the expiration of three years' service for confirmation in the permanent and pensionable establishment. Salary £480, rising to £920 a year. Outfit allowance of £60 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, preferably between 25 and 35 years of age, must have passed the examination for A.M.I.C.E. or possess a degree in civil engineering recognised by the Institution as exempting from Parts "A" and "B" of the examination. Must have had proper technical training and preferably have had not less than two years' subsequent experience on large engineering or municipal works.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting M/254. 7172

Engineers as Shown below REQUIRED by the GOVERNMENT of CEYLON for the Electrical Department for three years in the first instance. In each case free passages are provided, and, in the case of married men, for wife and children also, not exceeding four persons besides the candidate selected; and a rent allowance is paid if no quarters are available.
ASSISTANT CIVIL ENGINEER, Grade I (M. 320).—Salary £500-40-£960 a year. Candidates, age 22 to 35, must be corporate members of the Institution of Civil Engineers or hold an Engineering Degree or Diploma recognised as granting exemption from Sections "A" and "B" of the A.M.I.C.E. examination. They must be good draughtsmen and capable of designing and carrying out buildings, bridges and other engineering structures, preparing detailed plans, taking out quantities, and estimating. They must also have had experience in Surveying and Levelling.
ASSISTANT ELECTRICAL and MECHANICAL ENGINEER (M. 321).—Salary £300-25-£450-30-£600 a year. Candidates, age 22 to 35, must have had technical training and experience in works and Drawing-office and subsequent experience in the installation and operation of Electric Generator Plant, Distribution System, and also Testing of Electrical Plant and Machinery. They should also be corporate members or persons qualified on attaining the prescribed age to become corporate members of the Institution of Electrical Engineers. Preference will be given to those who also have a knowledge of Surveying and Levelling, and experience of Mechanical and Civil Engineering.
ASSISTANT ELECTRICAL ENGINEER (M. 322).—Salary £300-25-£450-30-£600 a year. Candidates, age 22 to 35, must have had technical training and experience in works and drawing-office, and subsequent experience in the installation and operation of Electric Generator Plant, Distribution System and also testing of Electrical Plant and Machinery. They should also be corporate members or persons qualified on attaining the prescribed age to become corporate members of the Institution of Electrical Engineers.
MAINS ENGINEER (M. 324).—Salary £600-40-£1000 a year. Candidates, age 30 to 45, should be corporate members by examination of the Institution of Electrical Engineers and have had good technical training, as well as experience in the Laying Out of A.C. and D.C. Mains Systems, the Laying of High-tension and Low-tension Cables and the Construction of Overhead Lines up to 33,000 volts. Testing, &c., and maintenance of same.
ASSISTANT ELECTRICAL ENGINEER, Grade I. (M. 325).—Salary £500-30-£920-40-£960 a year. Candidates, age 25 to 35, must have had experience in the installation and operation of modern Three-phase Power Supply System, including Conversion to Direct Current for Traction, &c. They should also have passed the examination for the Associate Membership of the Institution of Electrical Engineers or equivalent examination and be associate members of that Institution.
Apply at once by letter, stating age, qualifications, and particulars of experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting the reference number shown above against the vacancy for which application is being made. 7284

SITUATIONS OPEN

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The Engineer

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PUBLIC NOTICES

City of Liverpool.
JUNIOR MECHANICAL ENGINEERING ASSISTANT.
APPLICATIONS are INVITED for the POSITION of JUNIOR MECHANICAL ENGINEERING ASSISTANT in the City Engineer's Department, at a commencing salary of £230 per annum, increasing by £15 per annum to £260 per annum (Division "A").
Applicants should be not less than 25 years of age and should have good general mechanical engineering experience and be neat and accurate draughtsmen, capable of making working drawings.
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Applications, stating age, qualifications and experience, accompanied by copies of not more than three recent testimonials, endorsed "Junior Mechanical Engineering Assistant," to be delivered to Mr. T. Peirson Frank, M. Inst. C.E., City Engineer, Municipal Buildings, Liverpool, not later than 10 a.m. on Saturday, 31st December, 1927.
Canvassing, directly or indirectly, will be considered a disqualification.
WALTER MOON,
Town Clerk.
Municipal Buildings, Liverpool,
9th December, 1927. 7226

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THE PROPRIETOR of BRITISH PATENT No. 190,928, dated January 18th, 1922, relating to "Improvements in Drop Hammers," is DESIROUS of ENTERING into ARRANGEMENTS by way of LICENCE or OTHERWISE on reasonable terms for the purpose of exploiting the above PATENT and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. SINGER, Steger Building, Chicago, Illinois. 7260 H

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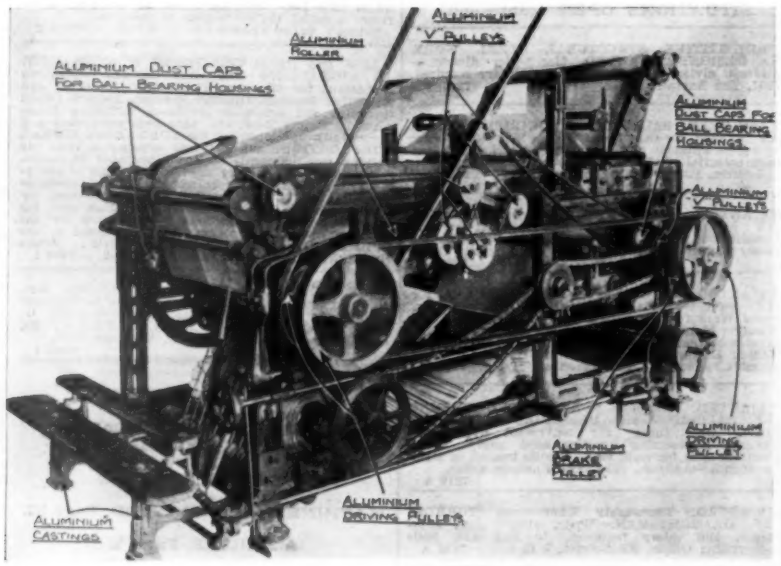

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A Seven-Day Journal

Suburban Traffic at Liverpool-street Station.

ACCORDING to a statement made by Mr. H. H. Mauldin, superintendent of the Eastern Section of the London and North-Eastern Railway, Liverpool-street Station, London, and the lines leading to it, constitute the most intensively steam-operated railway system in the world. Between Liverpool-street and Bethnal Green there are only three pairs of roads, and over these roads 1200 trains pass each day and 120,000 people are carried twice daily. Between five and six o'clock each evening 105 trains pass into or out of the terminus, many of which have to cross each other's path. The possibility of electrifying the system has not failed, and is not failing, to be studied, but at present the cost involved in the conversion is regarded as almost prohibitive. The needs of the growing population in suburban Essex are, however, not being neglected. Works involving an expenditure of £1,250,000 have been undertaken, including the provision of new rolling stock and track circuiting. Dealing with the railway's record of punctuality, Mr. Mauldin stated that, compared with 1913, 87 per cent. of the trains were not more than two minutes late, although 23 per cent. more trains were being run.

The Duddell Medal.

THE Duddell Medal for 1927 has been awarded by the Council of the Physical Society to Dr. F. E. Smith, F.R.S. This medal is presented annually for work in connection with the development of scientific instruments or of materials used in their construction. The award made to Dr. Smith is in recognition of his work on electrical standards. Since 1920 Dr. Smith has been the director of the Admiralty's Department of Scientific Research and Experiment. Before taking up that appointment he was at the National Physical Laboratory, where he acted as superintendent of the Electrical Department after 1901. At Teddington his early work included modifications of the Wheatstone and Kelvin bridges for precise measurements of resistance and the development of bridges for accurate platinum resistance thermometry. Later he did good work on the current balance, in the course of which he developed the Smith silver voltmeter. He has been honorary secretary of the British Association for the Advancement of Science since 1922, and in 1923 was elected President of the Physical Society of London.

"Road-Rail" Trucks on the L M S.

IT is announced by the London, Midland and Scottish Railway that it has completed its arrangements for putting into service a "road-rail" truck system for the transport of goods. The road-rail truck is described as involving the use of a container forming in effect the upper part of a railway wagon which can be exchanged between road and rail vehicles. These containers, it is claimed, will provide a means by which goods can be conveyed from door to door without the disturbance at stations which hitherto has been inseparable from the transport of goods carried partly by road and partly by rail. The system will, it is said, eliminate in addition packing costs, reduce the risk of damage to the goods or their loss by theft, save time and money, and speed up the goods services. In conjunction with the company's rail-head distribution depôts, of which more than 400 are now in existence, the scheme, it is claimed, will offer to British traders an attractive and efficient service for the conveyance of bulk traffic. The time is anticipated when it will be possible for a farmer, say, in Australia, to load his produce into a container which will remain unopened until it is delivered at an internal railhead distribution depôt in this country.

American Naval Proposals.

OFFICIAL particulars of the new American naval programme differ in certain respects from the forecast published in Washington last week. The proposals transmitted to Congress by the Secretary of the Navy call for the construction of twenty-five cruisers, nine flotilla leaders, five aircraft carriers, and thirty-two submarines. No mention is made of the four battleships which were said to be contemplated. These ships could not in any case be laid down before 1931–32 without infringing the Washington Treaty. It is officially announced that all the projected cruisers will be of the 10,000-ton class, armed with 8in. guns, and that the estimated cost per ship is £3,400,000. The flotilla leaders are to displace about 2000 tons and to cost £1,000,000, while the aircraft carriers will be ships of 13,000 tons, costing £3,800,000. The submarines are, apparently, to be of medium size, as the estimate of £1,000,000 per boat is considerably lower than that for the big fleet submarines of the "V" class, now being built. The total cost of the programme is put at something under £200,000,000. It is admitted in Washington that the plan is, as yet, only a paper one, which may never materialise. The idea is, seemingly, to use it as a bargaining asset in the event of a new disarmament conference being held. The Chairman of the House Naval Affairs Committee, who introduced the Bill, remarked later:—"I cannot tell whether this is a big programme or a little one. No time limit is set, and we can build these vessels in one year or in a hundred years." It has since been intimated that the Navy Department's actual programme for next year is restricted to five cruisers, four flotilla leaders, and seven submarines, and even this plan may be reduced in its passage through Congress.

Salving the Motor Tanker Seminole.

ON Thursday, December 15th, work was begun upon the salving of the cargo of the Anglo-American Oil Company's motor tanker Seminole, which went aground on the Pluckington sandbank in the Mersey on Tuesday, 13th instant. The salvage work was entrusted to Cammell Laird and Co., Ltd., of Birkenhead. The Seminole was built in 1921 by Vickers Ltd. and is a tank vessel of 9500 tons deadweight carrying capacity. She is propelled by twin-screw, six-cylinder oil engines of the Vickers four-cycle type, designed for an output of about 2500 S.H.P. At the time of her arrival in the Mersey she was returning from Texas with about 8000 tons of oil and petrol spirit in fourteen tanks. When she ran aground two of the main tanks, Nos. 5 and 6, were split open and about 2500 tons of inflammable liquid escaped, which caused the fire menace to the Liverpool docks to which we referred in last week's Journal. The other portion of the cargo was transferred to the Anglo-American Oil Company's tanker Taramac, which was specially brought over from Belfast and berthed in Brunswick Dock, about 100 yards from the stranded vessel. By means of wire ropes it was found possible to bridge this distance and support a 12in. flexible pipe, together with a smaller pipe for compressed air, which was used to work the pumps. The tanker was pumped out early in the week and on the morning of Tuesday, December 20th, she was finally refloated and safely berthed in the Brunswick Dock. The owners and salvors are to be congratulated on the success of their work.

The Electricity Commissioners Seventh Annual Report.

HAVING regard to the changed legislative conditions under which the electrical development of the country will henceforth proceed, the Electricity Commissioners have considered it desirable to review the progress during the past seven years in their recently issued annual report. At the commencement of 1920, the industry comprised 532 separate authorised undertakers, owning between them 475 generating stations containing approximately 2,309,000 kW of plant, or an average of about 4850 kW per station. In the course of the last seven years the Commissioners sanctioned the establishment of 117 new generating stations, involving the initial installation of 709,210 kW of plant. In Scotland the development of four hydro-electric schemes having an aggregate or potential capacity of about 153,000 kW was authorised by special Acts. The capacity of the new stations sanctioned by the Commissioners ranged from a few kilowatts to 100,000 kW. The majority of the new stations were small; in fact as many as seventy-nine involved the installation of plant of less than 250 kW, but the absence of any neighbouring transmission system or other source of supply left the Commissioners no alternative but to give their consent. Eleven stations with initial capacities of 30,000 kW or over accounted for 529,900 kW of generating plant, whilst eight others with initial capacities ranging from 10,000 kW to 20,000 kW accounted for 104,250 kW. The generating resources of the industry were also augmented by the completion of new stations which were begun prior to 1920, by the acquisition of various stations which were not at the outset the property of authorised undertakers, and by the accession of a number of non-statutory generating stations consequent upon the granting of supply powers to the owners of these stations.

The Schneider Trophy Race.

IT is announced that General Balbo, Italian Under-Secretary of State for Air, has taken advantage of a short visit to London to discuss with Sir Samuel Hoare, the future of the Schneider Trophy and in particular the desirability of holding the contest every two years instead of annually as at present. There is, it is said, general agreement that an interval of one year is insufficient to allow of adequate progress between successive contests in the technical design of marine aircraft, the development of which was the express object of the Trophy's founder, Monsieur Jacques Schneider, and that consequently an annual contest is not in the best interests of civil aviation. The Italian and British Governments have therefore decided that they will support the project for an amendment of the rules which at present govern the contest to provide that in future it shall take place biennially. Since time may not admit of a formal alteration of the rules before the date for entries for the 1928 contest, they have further mutually agreed to notify the aeronautical bodies concerned in Italy and Great Britain that they do not propose to support an Italian or British entry in 1928, provided the other countries which are possible competitors signify their willingness to adopt the same course. The United States, French and German authorities have been informally consulted and are understood to be in concurrence with these proposals.

Motor Shipbuilding Progress.

SOME interesting figures are given in an annual report on the progress of motor shipbuilding, which has been prepared by Mr. A. C. Hardy, the editor of *Motorship*, New York. At the end of the year 1927 there will be over 700,000 gross tons more ships equipped with marine oil engines under construction than those with marine steam engines. Since 1914 the highest powered vessel has increased from 2600 S.H.P. to 28,000 S.H.P. for the quadruple-screw Italian liner Augustus. Analysing the motor vessels of the world on a basis of national distribution, Mr. Hardy finds that, in spite of Great Britain being a coal-producing country, British shipowners now operate no less than 49 per cent. of the total motor tonnage of the world. Of this percentage the group of firms controlled by Lord Kylsant owns nearly 20 per cent., which amounts to about 9·2 per cent. of the world's motor ships, and is only a little less than the 9·6 per cent. of Italian-owned motor shipping. American owners, if small ships down to 300 tons gross be included, are responsible for about 25 per cent. of the world's total, and if the smaller ships are not taken into account the American quota approaches the Dutch figure 7·6 per cent. Scandinavian owners are responsible for 34 per cent., which figure is second to that of Great Britain. Mr. Hardy further points out that about 71 per cent. of the Scandinavian ships are engaged in tramp work, and he sees in this fact a confirmation of the oft-repeated statement that since the arrival of the motor vessel the tramp steamer is tending to disappear from the seas. It is fair to say, however, that most of the Scandinavian motor ships referred to are employed on long-term charter and are not therefore tramp vessels in the strict sense.

The Loss of the U.S. Submarine S 4.

WITH great regret we have to record the sinking of the United States submarine S 4, which was rammed by the coastguard destroyer Paulding off Provincetown, Massachusetts, on Saturday afternoon last, and went down in 100ft. of water with all hands aboard. The S 4 had just completed a trial after being reconditioned at the Portsmouth Yard, when, on rising to the surface, she was struck on the conning tower by the destroyer, which was steaming at a speed between 15 and 18 knots. As soon as the accident became known very complete naval salvage equipment was hurried to the spot and the wreck was located. Unfortunately, early salvage operations were ineffectual owing to bad weather. As the ship has a length of over 231ft. it was hoped to save six of the crew imprisoned in the torpedo room by lifting one end. Efforts to introduce air into the torpedo room where some six men were trapped, failed on Monday last. By means of Morse signals tapped out on the hull it was possible for the salvors to learn that Lieut. G. N. Fitch and five of the crew were still alive late on Tuesday afternoon, but were in urgent need of the supplies of oxygen and food, which, it was hoped, could have been introduced through a torpedo tube. As the gale was still strong on Tuesday evening it was feared that help would come too late, as signals from the interior of the submarine became fainter and were no longer heard late that evening.

Locomotives for South Africa.

IN a leading article published in THE ENGINEER last week we made reference to the contract for ninety locomotives for the South African Railways, which was then about to be placed. At that time nothing was known as to the successful tenderers, but we made the statement that with the best British representation possible it would probably be on price that British makers would fail. The correctness of that statement is borne out by the news from Johannesburg and Berlin that the order has been placed with German firms, the price for the ninety locomotives being given as £560,000. It is further stated that this order alone will be equal in value to about one-half the value of German locomotives exported last year and to about one-third of the estimated German export output for the present year. From the Johannesburg news it is to be gathered that the South African authorities felt that they had no other course open than to place the order with Germany, for the average British quotation, it is said, was about 28 per cent. above the average German price. It is well known that the German prices were cut to the bone, and many think that they do not leave a margin for profit; further, that in all probability the order will be found to have been taken at a loss. As a result of this order it may be expected that Germany will again take a prominent place in the competition for a further series of locomotives for South Africa, for which tenders will shortly be invited.

The Shannon Power Scheme.

No. IV.*

THE HEAD-RACE EMBANKMENTS.

ON the inner slopes of the head-race embankments the finishing work is now being carried out, whilst grass is beginning to grow on the outer slopes. Where the material is not sufficiently water-tight a layer of clay 60 cm. (23·6in.) thick is placed on the inner slopes and on the bed of the canal. To protect the

FIG. 41—ELECTRIC SWIVEL CRANE

slopes and bed from the eroding effect of the water a layer of broken stones 40 cm. (15·75in.) thick is also provided, and above this layer of stones on the portion of the slopes extending from 1 m. (3·28ft.) above high water to 1 m. below low water, concrete slabs are being formed to afford protection against wave action due to wind, or to a sudden stoppage of the turbines or to navigation. For this finishing work electric swivel cranes—see Fig. 41—are placed so that they have command of the whole of the slopes from the bottom of the canal to the top of the embankments, and they serve for placing the stones, &c., in position. The cranes have a reach of 15 m. (49ft.) and they can lift a load of 2 tons. Trains running on a railway track at the bottom of the canal bring clay, broken stones, top soil and aggregate for the concrete, and a row of steel skips placed alongside the tracks receives the contents of the trucks. After the embankment slopes have been levelled the cranes are brought into use. The skips are lifted and the material is tipped on to the slopes. Wherever necessary a layer of clay is provided, and in order to secure good adhesion it is rolled into the slopes. Broken stones are also deposited on the slopes by means of the swivel cranes, whilst higher up the concrete slabs —see Fig. 42—are formed. These slabs are 12 cm. (4·7in.) thick, 3 m. (9·84ft.) wide, and 8·95 m. (29·3ft). long. The concrete is mixed in a machne which runs along rails at the bottom of the canal, and after it has been placed in the steel skips it is lifted by the crane and placed on the slopes of the embankments. As the various portions of the work are all carried out close to one another, the crane can work without interruption. When a crane moves to a new position along the embankment it is necessary to level down the bed for the crane track, and that is done by means of a special rake which is operated by a winch driven by a 25 horse-power heavy oil engine. The winch runs on rails at the top of the embankments, and it also serves for operating the roller that is used on the slopes.

FIG. 42—CONCRETING THE INNER SLOPES OF THE HEAD-RACE EMBANKMENTS

* No. III. appeared December 16th.

THE WEIR.

The weir, which will raise the level of the river 7·55 m. (24·8ft.) above the present average level so as to take advantage of the fall in the river from the lake at Killaloe to Parteen Villa, where the work of constructing the weir and intake building is being carried out, will, as we have already stated, replace the existing Killaloe Weir, which has served for holding up sufficient reserve of water in Lough Derg during the dry season. As explained in our first article, for regulating the water level above the weir and to carry water away during floods, six sluice gates are to be provided—four 18 m. (59ft.) wide and two central deep sluices, 10 m. (or 32·81ft.) wide. The weir is designed so that even with one of the deep sluices in the centre closed for repairs, it can discharge the

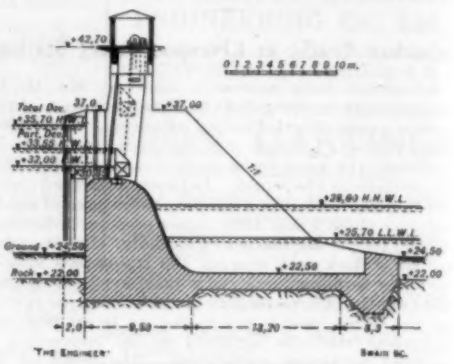


FIG. 43—CROSS SECTION OF WEIR

maximum flood of the Shannon, *i.e.*, 920 cubic metres of water per second, with the head-race closed. The outer sluices will be closed by steel roller gates each 18 m. (59ft.) wide by 2·7 m. (8·86ft.) deep, whilst

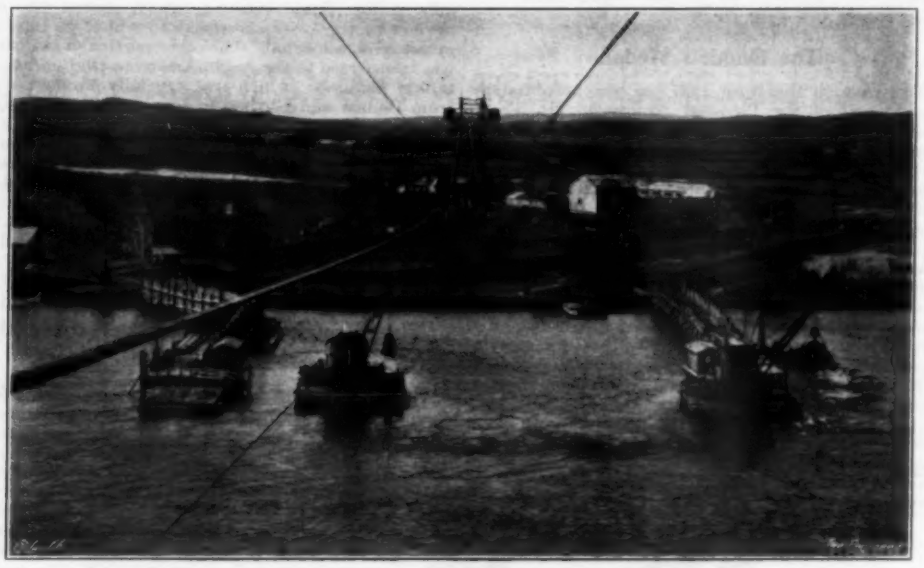


FIG. 44—CONSTRUCTION OF THE WEIR AT PARTEEN VILLA

the intermediate sluices will be closed by roller gates 18 m. (59ft.) wide by 3·5 m. (11·5ft.) deep. Each of the 10 m. wide central sluices, or flush controllers, will be closed by a double roller gate divided horizontally and having a total depth of 10·9 m., or 35·8ft. The hoisting machinery, which will be capable of being operated electrically or by hand, will be placed on a roofed gangway—as shown in the cross-section, Fig. 43. As a safety measure and for cutting off water during repairs to the sluices, recesses for stop beams

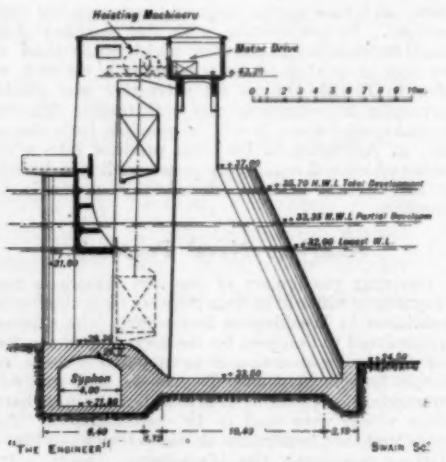


FIG. 45—CROSS SECTION OF INTAKE

are to be provided in the piers, and it will be possible to lower these beams into position by means of a crane. To prevent erosion, spillway basins faced with granite will be provided below the weir. A fish pass, designed in accordance with recent practice, is to be provided on the river at the weir. All the work will be founded on the old sandstone. To enable the normal flow of the river to be maintained for navigation purposes while the work is in progress, the weir is being built in two parts. The work is

being done in a dry pit between cofferdams, and its erection, especially in winter time, is a difficult task because of the strong current of water. As the dam must be built on solid foundations, the loose stones and earth on top of the rock must first be removed, and for carrying out this work two grab excavators mounted on pontoons—as shown in Fig. 44—are employed. When the diver reports that the rock is free of all loose material holes are bored for the insertion of the two rows of "I" beams which form the outer walls of the cofferdams, consisting of sheet piling. After the work of strengthening and connecting the bars has been carried out, and after the outer walls have been put in position, the lower part of the intermediate space is filled with concrete and the upper part with good water-tight clay.

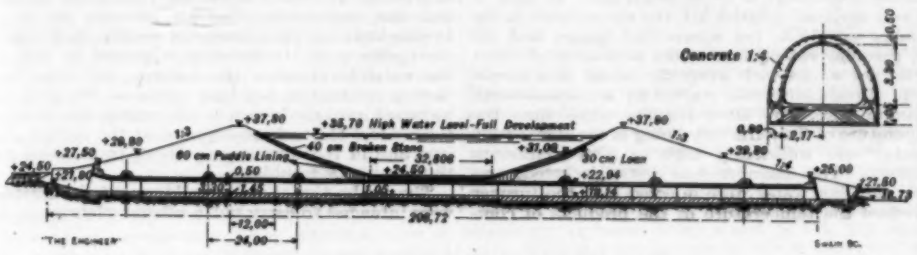


FIG. 46—LONGITUDINAL SECTION OF BLACKWATER CULVERT

The Intake.

The intake, of which we give a cross-section in Fig. 45, is on the right side of the weir when looking downstream. As shown in Fig. 3 in our first article, it will have three openings, 25 m. (82ft.) wide, and it will be possible to close all these openings with the aid of steel sluices in a manner similar to that adopted on the weir. The same kind of rock as that on which the weir is built is to be found on the right bank of the Shannon about 3 m. (9·84ft.) below the surface, and this rock is being used for the foundation of the intake building. The excavation of the foundation for this building was done in an open pit partly by a shovel excavator and partly by hand. The raising of the level of the river by 7·55 m. (24·7ft.) renders it necessary to protect the land which lies above the weir and intake building from floods. On the right side of the river this protecting bank forms a continuation of the bank of the head-race up to the Ardclooney River, where the land is higher, whilst on the left bank the protecting bank is connected with the weir and runs further along the river until it merges into a hill at Fort Henry.

The Culverts and Syphons.

About a mile above the small town of O'Briensbridge the head-race branches off the river Shannon and, adapting itself to the lie of the land, it extends in a long drawn out channel to the power site of Ardnacrusha. During its course of about 12½ kiloms. (7¾ miles) it crosses several roads, and as mentioned in a previous article, various watercourses, which have to be carried under the sole of the head-race. In parts, where the head-race is high enough, the water of the various streams can be conveyed under the head-race by ordinary culverts or conduits, but, where the head-race cuts deeply into the land, it is necessary to pass the water of the streams under the head-race by means of syphons. For the most part the culverts are constructed on quite simple lines, and their design did not present any real problems, but the design and construction of the syphons was rather more difficult. One of the culverts has to deal with the Blackwater River, which, although under normal conditions it is little more than an unassuming brook that meanders along between steep embankments, after heavy rainfalls becomes a raging torrent and discharges up to as much as 50 cubic metres (11,000 gallons) of water per second. In order to keep the dimensions of the culvert within reasonable limits, a speed of 4·4 m. (14·4ft.) per second was chosen for the discharge of the flood water at times of the maximum flood level, which only occurs during a few days of the year. Consequently the structure will only have to withstand the effect of this high velocity on those rare occasions. In order to facilitate the change from the lower speed of the water in the river to the higher speed in the culvert a steep sill has been provided at the inlet of the culvert. The ground on which this culvert is built is composed of loamy sand in which few stones are embedded, and it is able to support a considerable load when dry, but in the wet state it is less reliable, and that naturally had to be taken into account when laying the foundation of the structure. The culvert is covered by an earth embankment 15 m. (49·2ft.) high, and in order that the pressure may be dealt with in a satisfactory manner, the arch is suitably proportioned and is provided with iron reinforcements. The arch of the culvert is situated about 1·56 m. (5·1ft.) below the sole of the head-race, and, in order to prevent the percolation of water from the head-race into the culvert, layers of puddle clay have been applied to the bottom of the head-race and to the embankments, the clay being covered with a layer of stone to protect it against erosion caused by the flowing water in the head-race. Round the arch of the culvert concrete rings have been provided at intervals to prevent water flowing along the concrete arch in the longitudinal direction of the culvert. The work of constructing the culverts was commenced in April of last year, when an old mill was pulled down and the building pit for the Blackwater culvert was excavated by means of a steam shovel mounted on caterpillars, and having a capacity of 0·8 cubic metre per stroke. Before the excavation of the building pit, having a total length of 220 m. (722ft.), had been completed, the work of constructing the culvert was commenced where the building pit had been finished. Commencing at the lower end, the culvert was constructed in sections 12 m. (39·4ft.) long, and in the first instance every second section was omitted, but afterwards the remaining sections were constructed and the joints between the sections were sealed with bitumen to prevent the entrance of water. In the middle of July, 1926, a portion of the culvert was ready to take the water of the Blackwater River, which was led into the finished part through an opening in the arch, thus enabling the work on the head-race embankment to be carried on, whilst the upper part of the culvert was also completed. The construction of this culvert—of which we give a longitudinal cross-section in Fig. 46—involved the excavation of 8800 cubic metres (310,000 cubic feet) of soil, and the placing of 3700 cubic m. (130,000 cubic feet) of concrete and reinforced concrete. Besides this large culvert for the Blackwater River, several small culverts and syphons are being built at different parts of the head-race, one of the most notable being the Annengrove syphon. An illustration showing the Blackwater culvert in the course of construction is given in Fig. 47.

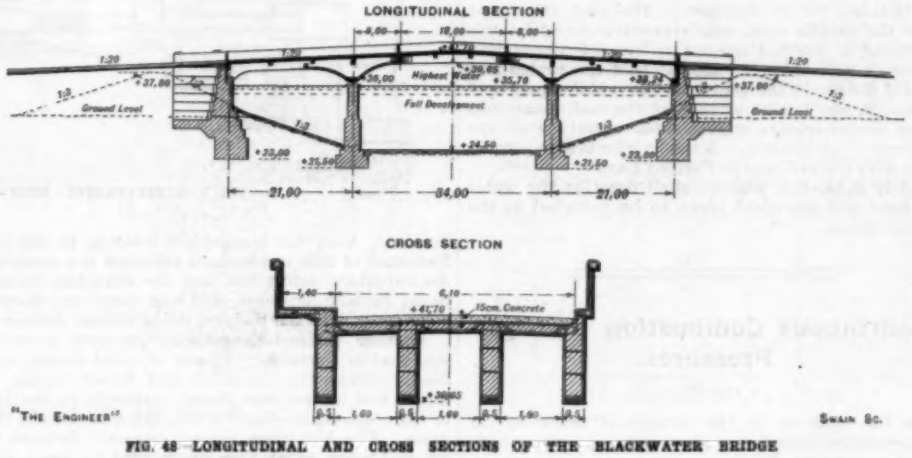


FIG. 48—LONGITUDINAL AND CROSS SECTIONS OF THE BLACKWATER BRIDGE

FIG. 47—THE BLACKWATER CULVERT UNDER CONSTRUCTION

Bridges Over the Head-race.

It has been necessary to build three bridges over the head-race, one at Blackwater, near Ardnacrusha, one at Clonlara, and one below the weir. In all three cases these bridges are constructed of reinforced concrete, and they present a good appearance. The Blackwater Bridge—see Fig. 48—serves to carry the road from Limerick to Broadford over the head-race. Heavy traffic between Limerick and East Clare will pass over this bridge, which is at present being used by the vehicles that transport the materials needed for the various building sites. Where the bridge has been built the road had to be slightly diverted. The bed of the canal under the bridge is at a level of 24·5 m. (80·4ft.) O.D., the water level for the partial development scheme being 33·5 m., or 109·9ft. O.D., and for the full development scheme 35·7 m., or 117ft. O.D. To enable the canal to be used for navigation purposes the bridge had to be raised to a height of 41·7 m. (137ft.), and ramps lead to the bridge and rise gradually to the maximum level at the centre. The superstructure consists of reinforced concrete three-span cantilevers, with a suspended centre girder, the centre span being 34 m. (111·5ft.) long, whilst the distance between the abutments is 76 m., or 249ft. The end spans are formed by longitudinal beams, which rest on piers and the abutments, and they project into the middle span, thus forming cantilevers. To allow for expansion and contraction, steel bearings are provided on the piers and abutments, and on the projecting arms of the cantilevers to support the centre girder.

The width of the bridge roadway is 6·1 m., or 20ft., and on one side there is a footpath 1·4 m., or 4·6ft. wide. The four main longitudinal beams, which are 4 m., or 13·12ft., deep and 50 cm. (19·7in.) wide, form the main part of the superstructure, and on top these beams are spanned by the roadway slab. The reinforcement of the main beams is composed of round

bars 36 mm. in diameter. The concrete for the piers and abutments is composed of eight parts of aggregate and one part of cement, whilst that for the superstructure was made with 4½ parts of aggregate and one part of cement. Limestone crushed in the crushing and washing plants at Ardnacrusha and Clonlara was used for the aggregate.

A concrete mixer of ½ cubic foot capacity was employed for mixing the concrete, which was tipped into elevators that conveyed it to trucks running on a 60 cm. track on the top of the bridge. The concrete mixer was able to provide 75 cubic metres (2648 cubic feet) of concrete per ten-hour shift, the total amount of concrete used for the bridge being approximately 4000 cubic metres or 141,200 cubic feet. Day and night shifts were worked during the whole time the bridge was being constructed, and approximately twenty-five men were kept busy mixing and placing the concrete and carrying out the necessary earth work, whilst a gang of ten men was engaged on the shuttering and scaffolding work. The lower part of the centering for the superstructure of the bridge was composed of lateral horizontal rows of beams at approximately the same level as the bearings. On top of these beams jacks with a maximum lift of 20 tons were placed, and the top part of the centering was built on these jacks, which were used to simplify the lowering of the centering after the bridge had been built. The centering was designed so that it could be made use of in connection with the erection of the reinforced concrete bridge across the head-race at O'Briensbridge. The centering was lowered on October 1st of this year. The part associated with the middle span was lowered first, whilst the centering of the end spans was lowered afterwards. Accurate measurements showed that the bridge had settled 5 mm. in the centre of the middle span, and 2 mm. in the centres of each of the end spans, and these measurements corresponded exactly with the engineer's calculations. A steel girder bridge is to be built over the tail-race at Parteen Lax.

Early in the new year we shall describe the water turbines and electrical plant to be installed in the power-house.

Continuous Combustion at High Pressures.

By E. C. WADLOW, Ph.D., B.Sc.

IF the pressure in the furnace is taken as the criterion, combustion of fuels may, in general, be divided into two classes.

In those cases in which the pressure in the combustion chamber is atmospheric, or nearly so, supplies of fuel are usually fed continuously to the burner, and what may be termed "continuous combustion" takes place; while if the pressure is considerably above atmospheric, it is usual to supply charges of air and fuel intermittently to the combustion chamber, and, after combustion, to expel them mechanically before introducing a new charge. Both these methods are universally employed, the former being that used in

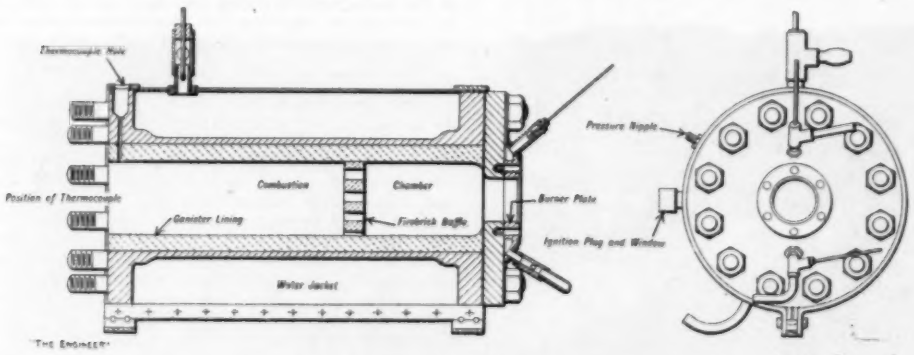


FIG. 1—GENERAL ARRANGEMENT OF COMBUSTION CHAMBER

boilers and furnace work generally, while the internal combustion engine is typical of the latter class.

In view of the enormous importance of the process of combustion of fuel, and of the great amount of time applied to its study and development, it is surprising that continuous combustion at pressures greatly above atmospheric finds practically no industrial application, and has received very little attention. Indeed, there is very little information dealing with this problem.

A brief description, therefore, of an experimental furnace which the writer had occasion to construct some little time ago to supply a quantity of gas at elevated temperatures and pressures may be of value. Although there must be numerous instances of plants working under what is here termed "high pressure" conditions, very few have apparently been described, and of them, three may be referred to here to show the peculiar circumstances in which continuous combustion at elevated pressures has been employed in the past.

One example is that of the Armengaude and Lemale internal combustion turbine, which has been described and discussed many times.[1] It is therefore sufficient to state that the interior of the combustion chamber was pear shaped, the fuel and air being fed in at the one end, and the products of combustion escaping through a nozzle in the other owing to the pressure difference inside and outside the combustion chamber. The details and dimensions available are unfortunately insufficient to be of much use. In each of the two turbines constructed, the air pressure in the chamber was 75 lb. per square inch gauge, and the fuel, paraffin, was injected under a pressure of about 100 lb. per square inch gauge by means of a special pump. Combustion was started by an incandescent platinum wire, but after running some time the temperature of the refractory lining of the combustion chamber was sufficiently high to give continuous burning. The chamber was water jacketed, and steam and hot water were injected into the furnace to reduce the temperature of the products of combustion. Very few particulars relating to the performance of this combustion chamber are available. An important defect was that the refractory furnace lining became detached, and was swept out through the nozzles into the turbine, doing serious damage.

Another interesting constant-pressure generator was that of Garland.[2] It was of novel design, combining combustion chamber and boiler in one. A liquid fuel burner was placed vertically in the base of the combustion chamber beneath a horizontal tube plate. The hot gases passed upwards through the vertical tubes, which were surrounded by water, as in a fire-tube boiler. There was no upper tube plate, however, and the products of combustion were allowed to mix with the steam generated, the mixture being drawn off through a valve at the top. Some difficulty must have been experienced in keeping the water level constant, although various ingenious devices were used. Furthermore, difficulty was experienced in lighting up, from spluttering of the flame, from incomplete combustion and from melting of the fire-brick in the lower portion of the apparatus. The highest temperature reached above the steam space was about 320 deg. Cent. The fire-brick lasted about four hours, and melted before any comprehensive tests could be carried out.

The author described two methods employed in lighting up. In the first method, a small quantity of petrol was poured into the burner, and ignited by a torch. The air was slowly turned on, and then the paraffin under pressure was admitted. He stated that it required considerable practice to obtain a bright, steady flame, but once the flame was burning steadily, a combined torch plug and window was inserted in the base, and the pressure raised to 100 lb. per square inch gauge by throttling the exhaust gases. In the second method, a pressure of about 60 lb. per square inch was maintained in the generator, and electric sparks were passed close to the burner as the fuel was turned on. With this method, it was necessary either to preheat the burner or to start up on petrol. The first method was stated to be the more satisfactory, as in the second instance the sparking plug quickly burnt out.

The third plant to be noticed is the internal combustion boiler described by Brünler.[3] In this boiler the flame is actually submerged in the water, and, as with the generator of Garland, the boiler pressure and the combustion chamber pressure are equal. In this instance, the pressure is usually about 144 lb. per square inch. Combustion is started by reducing the water level below the burners, but once satisfactory combustion has been obtained, the level may be raised until the burner is submerged, and provided the air and the fuel are supplied at the correct pressure and in the correct proportion, combustion continues without trouble.

The combustion chamber and burner to be described were intended to carry out a scheme planned on less ambitious lines than those already referred to, inasmuch as the boiler was entirely absent, water being employed merely as a cooling fluid. Hence the gases escaping from the combustion chamber were entirely products of combustion. The only stipulation was that the furnace should be capable of supplying products of combustion at widely varying temperatures and pressures without excessive trouble with the regulation.

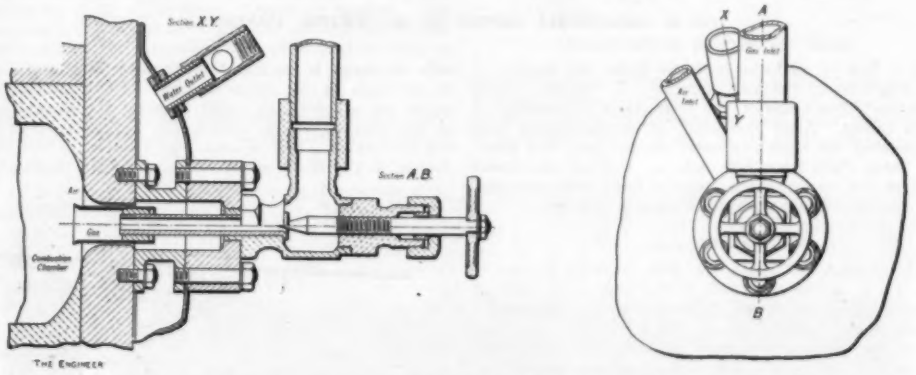


FIG. 2—EXPERIMENTAL HIGH-PRESSURE SINGLE JET GAS BURNER

The design of the chamber is shown in Fig. 1. The main portion consisted of a piece of steel tube, 2ft. long and 7in. internal diameter, having flanges welded on to both ends. In this tube was placed a lining of ganister, 1in. thick, leaving a hole of 5in. diameter up the centre of the pipe, in which a piece of fire-brick was inserted as shown. Bolted to one end was a steel plate which carried the burner, while at the other was another steel plate of equal thickness, which contained the orifice through which the gases passed under pressure after combustion. The orifice was ¼in. diameter. This end plate is not shown in Fig. 1.

Both plates were provided with water jackets, while the space between the flanges on the pipe was similarly employed as a jacket for the main surface of the furnace. The water supply to each jacket could be regulated independently, and pockets were arranged as shown for thermometers to detect overheating.

The pressure in the furnace was indicated by a Bourdon gauge having an 8in. dial, the pressure hole being drilled in the main pipe flange. Another hole in the same flange accommodated a platinum platinum-rhodium thermo-couple, the head of which was designed specially to withstand pressure and heat, the stem being placed vertically to avoid trouble from sagging. The cold junction and millivoltmeter were placed in a convenient position some distance away. The couple was calibrated against the freezing points of a number of pure metals up to the freezing temperature of copper.

The fuel employed was Mond gas. This, and the air for combustion, was led under pressure from compressors through separate orifice meters. These meters were calibrated as carefully as possible, though the accuracy was necessarily somewhat lower than in the case of the other instruments. The error, however, decreased as the pressure increased, and over the range covered was probably less than ± 2 per cent.

In the absence of comprehensive data on combustion at the pressures desired, and owing to the impossibility of estimating the pressure drops through the burner and consequent air and gas velocities, resort was made to actual experiment for information.

The first burner constructed was of a simple type, and is shown in Fig. 2. The air and the gas were kept separate until they entered the combustion chamber in concentric layers, the quantity of each being regulated by stop valves in the pipe lines above the burner. An additional needle valve was provided to give a finer regulation of the gas supply.

The method of lighting up was as follows:—The small plug containing a plate glass window—shown in Fig. 1—was removed, and the air turned on to dis-

[1] *Cassiers' Magazine*, 1908; also THE ENGINEER, Vol. CXXX., No. 3514, May 4th, 1923, *et seq.* W. J. Stern, Aeronautical Research Committee, Engine Sub-committee Reports, No. 54.

[2] *Engineering Magazine*, August, 1906; also G. B. Warren, *Wisconsin Engineer*, Vol. 26, No. 2, November, 1921,

[3] *Chemistry and Industry*, February 20th, 1925.

place any gas, burnt or unburnt, present in the combustion chamber. After shutting off the air, a small auxiliary gas flame was introduced into the chamber through the plug hole already referred to, this being 4in. long and ¼in. diameter. This operation at first gave considerable trouble, owing to the extinction of the flame, but with practice and by using the most suitable tube diameter and flame length—which were found to be respectively ⅜in. and 2in.—the flame could be introduced with regularity. The main gas supply was then turned on, under a low pressure, followed immediately by the air supply. In the early attempts, the flame usually died out quickly, but again there was a gradual improvement. When combustion was proceeding satisfactorily, the plug and window was inserted, and the pressure in the chamber increased by increasing the quantity and pressure of the separate air and gas supplies.

Combustion, however, was exceedingly unstable with this burner, and on one occasion only was it possible to reach a pressure of 15 lb. per square inch. A number of experiments, using different sizes of tubes, when the burner was attached to, and removed from, the combustion chamber, seemed to indicate that the gas and air velocities respectively were too high. The control of this burner also seemed to be too delicate to be carried out manually.

With a view to overcoming these difficulties, a burner was designed—Fig. 3—which embodied a

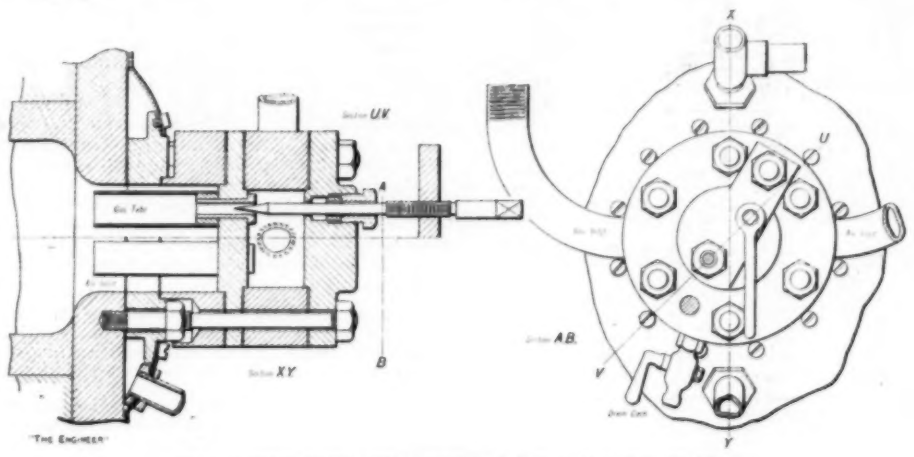


FIG. 3—EXPERIMENTAL HIGH-PRESSURE MULTI-JET GAS BURNER

novel feature. The single gas tube used in the first burner was replaced by four of the same size. The gas nozzles which fed them were of different sizes, however, two being fitted with needle valves to give further means of regulation. The diameters of the nozzles were ¼in., $\frac{9}{32}$in., and those fitted with needle valves, $\frac{9}{32}$in., respectively. The object of having gas nozzles of different size in conjunction with gas tubes of one diameter, namely, ⅜in., was to ensure always having gas leaving one tube with a velocity relative to the entering air such that combustion would be maintained.

Assuming the air and the gas to be supplied to the burner in the correct proportion to give maximum temperature on combustion, there is one relative air-to-gas speed giving optimum steady burning. The range of velocities on either side of this figure which will give satisfactory results, being dependent upon the composition of the gas supply, the turbulence of the respective air and gas supplies, and also upon the type of burner, cannot be stated numerically to cover various conditions, but clearly the range is limited. The chief trouble, as shown by preliminary tests, was that the flame literally blew itself out—a trouble, incidentally, experienced previously by others.

This difficulty is almost entirely obviated by the multi-jet burner, owing to the greatly increased range of relative air-to-gas velocities obtained. For instance, supposing the velocity of the gas issuing from the tube having the $\frac{3}{16}$in. nozzle to be represented by unity, that of the gas leaving the tube with the ¼in. nozzle will be 1·77, that from the tube with the $\frac{9}{32}$in. nozzle—needle valve being fully open—will be 2·25, and any velocity below unity may be obtained with the remaining gas tube. Thus, fairly wide variations in the air and gas supply pressures are automatically allowed for in this burner, for if a blow-out occurs at one tube, owing to excessive velocity, it is more than likely that the velocity at a neighbouring tube will be such as to maintain combustion. Meanwhile, the gas leaving the tube giving excessive velocity is consumed further along the furnace. Complete immunity from stoppage can only be ensured, of course, by the use of many nozzles, but even for a fairly wide range of conditions, such as those outlined below, four appear to be ample.

As the furnace described above was an auxiliary to other apparatus, and proved equal to the work demanded of it, no careful tests were carried out to determine its efficiency by measuring the heat distribution to exit gases and to furnace walls after combustion, but some further figures and details concerning the behaviour of the plant may be of value.

(1) The gas used varied slightly in composition from day to day. A few analyses will suffice to show this variation :—

TABLE I.

Test No.	1A	5	8
Combustion chamber pressure, lb. per sq. inch gauge	30	70	100
Per cent. analysis by volume—CO_2	8·8	6·9	8·4
O_2	0·4	0·5	0·1
CO	17·5	21·0	22·0
H_2	22·7	26·3	27·6
CH_4	3·5	2·1	3·8
N_2	47·3	43·2	38·1

(2) The maximum pressure which could be reached was limited by the gas compressor in this instance. When burning a mixture of correct strength, a maximum combustion chamber pressure of 100 lb. per square inch gauge was reached, but with weaker mixtures, higher pressures could be obtained. Any pressure up to 100 lb. per square inch gauge presented no difficulty whatever. At the higher pressures there was some fluctuation in the furnace pressure, the maximum variation being about ± 1 lb. per square inch. This was thought to be due to inefficient and irregular mixing of the gases just prior to combustion.

(3) The maximum temperature recorded was 1435 deg. Cent. absolute at 100 lb. per square inch gauge pressure. This could be maintained indefinitely without trouble of any description.

(4) Satisfactory combustion was possible over a wide range of mixture strengths. Thus almost any temperature up to the maximum stated above could be obtained. Some idea of the relationship between mixture strength and temperature may be gathered from Fig. 4, in which temperature is plotted against air/gas ratio by weight for a few pressures, these being indicated on the figure. The gas analyses for these tests are those given in Table I.

The maximum temperature attainable with constant mixture strength is considerably raised by increasing the pressure in the combustion chamber. From a number of tests carried out, the increase appeared to be approximately 40 deg. Cent. for each 10 lb. per square inch increase in pressure. The

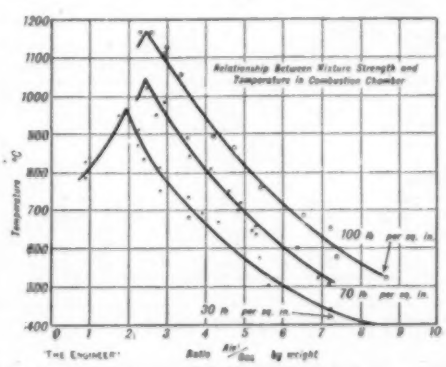


FIG. 4—MIXTURE STRENGTH-TEMPERATURE RATIOS

maximum temperatures recorded in a series of tests at various pressures are plotted in Fig. 5. It must be observed, however, that these figures have not been corrected in any way, for although variations in the composition of the gas produce variations in its calorific value, specific heat, and quantity of air required to give correct mixture strength, which could be allowed for, there still remain several other unknown variables which make correction of any type unwarranted. It is sufficient to say, therefore, that the analyses of the gases used varied little from those given in Table I., and that the temperatures of the gas and air supplied to the burner were usually about 20 deg. Cent.

(5) Combustion was more stable when the pressure of the gas supply exceeded that of the air supply, especially at the higher pressures. The actual pressure drop across the burner was not measured, and overall pressure drops across the regulating valve and burner considered as a unit give information of uncertain value. Under favourable circumstances, however, the pressure drop necessary to maintain flow of gases may be very small, and on two or three occasions the overall drop across valve and burner was about 0·3 lb. per square inch. The throttling at the stop valve is mainly responsible for this loss.

(6) The plate glass window was practically useless for giving indication as to the state of combustion, owing to the restricted view obtained. Unless it is possible to see the whole of the flame, it is exceedingly difficult to estimate the state of combustion in the furnace.

(7) A thermo-couple provides an excellent tell-tale as to the state of combustion, for variations are recorded almost instantaneously and the galvanometer employed may be made deadbeat. The wide range of flame temperatures possible gives considerable movement of the millivoltmeter needle.

(8) The quantity of air and gas entering the combustion chamber was sufficient to keep the burner cool enough to handle, and even the gas tubes, exposed to the heat of the furnace, stood up well, owing, no doubt, to the continual flow of cool gases over their inner and outer surfaces.

(9) No trouble was experienced with the ganister lining beyond some shrinkage, and consequent cracking, taking place. No portion became detached, but it is obvious that very careful consideration must be given to the selection of the material and to the method of holding it in position if trouble is to be avoided.

(10) It is advisable to separate as much as possible of the oil and water carried in suspension by the air and fuel, when these are compressed and cooled again to atmospheric temperature. Passing these through receivers of considerable volume is not always sufficient to remove any large proportion, and care

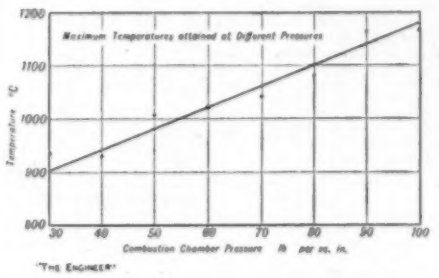


FIG. 5—TEMPERATURE-PRESSURE RATIOS

must be taken in arranging the pipe work to ensure the best results being obtained. Should continuous working over long periods be desired, it would be preferable to install a special separating apparatus.

(11) Hand adjustment of the valves regulating the flow of air and gas, while being necessary in an experimental plant, would be undesirable for continuous working under steady conditions. Pressures show a tendency to creep in both directions, and an initial slight alteration in any one, produces in turn a change in the others. Furthermore, the changes may be cumulative. Automatic pressure regulators may therefore be regarded as essential to secure stable conditions unless the pressures are watched very carefully and adjusted frequently.

Stop valves of the ordinary pattern are too coarse to provide the degree of close regulation necessary, and special needle valves would probably prove preferable.

(12) The experiments described show that satisfactory continuous combustion can be maintained in a chamber of small capacity.

It is obvious, from the temperatures recorded, that the heat losses are considerable. In the interests of obtaining a small heat loss, it is essential that the surface exposed should be as small as possible, and it is therefore distinctly unfortunate that time did not permit of a complete examination of the losses.

The maximum rate of combustion of gas in these experiments was about 1 lb. per minute, and under these conditions, approximately 3·4 lb. of fluid pass through the burner in the same period of time. The average length of time a molecule of gas spends in the combustion chamber is, therefore, about 0·1 second. There is every prospect, therefore, of being able to increase the weight of fuel burnt per cubic foot of combustion space without much fear of losses due to incomplete combustion, and at the same time a considerable reduction in the heat loss may be brought about.

Comparison with figures obtained from steam boilers, on the one hand, or with those from internal combustion engines on the other, is difficult, however, and probably misleading; the conditions of working and the objects in view vary in each case.

In conclusion, it may be mentioned that the above statements are based upon the experience gained during about 150 hours running with combustion taking place, and give, it is hoped, a true representation of the main difficulties likely to be encountered with plants employing combustion of gaseous fuel at high pressures.

H

Institution of Mechanical Engineers.

ON Friday evening of last week Mr. Lawford H. Fry presented before the Institution of Mechanical Engineers a paper, entitled "Some Experimental Results from a Three-cylinder Compound Locomotive." The meeting was moderately well attended for a paper dealing with locomotives. Elsewhere in this issue we begin the reprint of Mr. Fry's paper.

Sir Henry Fowler, the President, opened the discussion. He said he was an advocate of the compound locomotive, both by reason of the results which it yielded on the testing plant and from the service which it gave on the road. He believed that the Royal Scot would have been more economical if it had been built with compound cylinders and given a higher a simple type of locomotive. He also gave some figures obtained with his company's three-cylinder compound on the same road, and some obtained in connection with tests referred to by Mr. Dahlerus in his paper before the Institution in February, 1925. Unfortunately there was not at present in this country a locomotive testing plant similar to that on the Pennsylvania Railroad at Altoona, although the question of providing one had been under consideration for some time. Mr. Gresley, in his recent Presidential address to the Institution of Locomotive Engineers, put forward a proposal on the subject. The figures he was exhibiting that night, he continued, gave the coal and water consumption based on the drawbar horse-power hour as a unit. With the same locomotive the consumption would vary somewhat with the weight of the train behind the drawbar, all other things being

DYNAMOMETER TESTS OF L.M.S. LOCOMOTIVES—SUMMARY OF RESULTS.

Road	Crewe–Euston and return		Crewe–Carlisle and return		Crewe–Carlisle and return		Crewe–Carlisle and return	
Engine	No. 5917 standard "Claughton"		No. 5917 standard "Claughton"		No. 5923 modified "Claughton"		No. 1073 standard compound	
Date (1927)	Jan. 20th and 21st.		Feb. 8th and 9th		Feb. 1st and 2nd		Feb. 3rd and 4th.	
Weight behind tender, tons	375·6	384·6	315·6	315·6	319·6	333·6	280·6	314·6
Total weight, including engine, tons	488·1	495·1	426·1	426·1	430·1	444·1	370·0	412·0
Coal per mile, lb.	48·75		44·5		40·0		34·1	
Coal per D.H.P. hour, lb.	5·18		4·86		4·04		3·78	
Coal per ton-mile, including engine, excluding shed duties, lb.	·099		·1043		·0915		·0866	
Coal per sq. ft. of grate per hour, lb.	84·6		81·25		65·4		60·15	
Water, lb. per lb. of coal	6·83		6·96		7·06		Water figures not obtained	
Water, lb. per D.H.P. hour	35·34		33·85		28·56			
Water, gallons per mile	33·23		31·0		28·21			
Average speed, m.p.h.	55·0	53·0	51·1	48·5	51·3	48·6	50·5	49·4
Work done in H.P. hours	1392·7	1581·1	1240·133	1343·304	1430·9	1363·1	1164·2	1388·6

Royal Scot, Engine No. 6100.

Road	Euston to Crewe.		Crewe to Euston.		Crewe to Euston.	Euston to Crewe.
Date (1927)	Oct. 24th.	Oct. 26th.	Oct. 25th.	Oct. 27th.	Nov. 28th.	Nov. 29th.
Weight behind tender, tons	496·6	495·6	497·6	501·6	551·6	550·6
Total weight of train, including engine, tons	617·2	616·2	618·2	622·2	672·2	671·2
Coal per mile, lb.	46·4	47·7	43·1	44·5	45·2	58·2*
Coal per D.H.P. hour, lb.	3·31	3·09	2·72	2·85	2·66	2·77
Coal per ton mile, including engine, excluding shed duties, lb.	·075	·077	·070	·072	·082	·106*
Coal per sq. ft. of grate per hour, lb.	81·08	70·3	76·5	77·3	73·9	83·5
Water, lb. per lb. of coal	7·2	7·37	8·67	8·53	8·4	8·02
Pounds of water per D.H.P. hour	23·8	23·3	23·6	24·3	22·3	22·3
Water, gallons per mile	33·3	36·1	37·5	37·9	38·0	46·7
Average speed, m.p.h.	54·4	54·4	55·2	54·3	51·0	44·7
Work done in H.P. hours	2216·9	2443·9	2516·6	2471·6	2697·5	3375·5

* Coal high due to seven booked stops. Steaming good.

Royal Scot, Engine No. 6100.

Road	Euston to Carlisle.		Carlisle to Euston.		Euston to Carlisle.	Carlisle to Euston.
Date (1927)	Oct. 31st.	Nov. 2nd.	Nov. 1st.	Nov. 3rd.	Nov. 23rd.	Nov. 24th.
Weight behind tender, tons	419·6	420·6	420·6	420·6	449·6	449·6
Total weight of train, including engine, tons	540·2	541·2	541·2	541·2	570·2	570·2
Coal per mile, lb.	39·2	40·4	44·7	40·9	38·9	38·8
Coal per D.H.P. hour, lb.	3·19	2·94	3·32 estimated	2·86	2·92	2·82
Coal per ton-mile, including engine, excluding shed duties, lb.	·073	·074	·082	·076	·086	·086
Coal per sq. ft. of grate per hour, lb.	67·2	68·7	71·9	61·5	66·0	63·8
Water, lb. per lb. of coal	8·45	8·38	7·96	8·53	8·26	9·14*
Pounds of water per D.H.P. hour	27·1	24·7	26·5	24·4	24·0	25·8
Water, gallons per mile	33·1	33·9	35·5	34·9	32·0	35·6
Average speed, m.p.h.	52·7	53·0	50·3	47·2	53·0	51·3
Work done in H.P. hours	3676·3	4107·2	4028·0†	4294·8	3990·3	4124·3

* Tender feed connections leaking. Figures too high. † Estimated. Integrator bracket broke.

Royal Scot, Engine No. 6100.

Road	Crewe to Carlisle.		Cralisle to Crewe.		Crewe to Carlisle.	Carlisle to Crewe.	Glasgow to Carlisle and return		Glasgow to Carlisle and return	
Date	Nov. 7th.	Nov. 9th.	Nov. 8th.	Nov. 10th.	Nov. 11th.	Nov. 12th.	Nov. 15th.		Nov. 16th.	
Weight behind tender, tons	411·6	432·6	405·6	432·6	451·6	455·6	(a) 277·6 (b) 420·6	(c) 421·6 (d) 297·6	(a) 297·6 (b) 421–6	(c) 420·6 (d) 297·6
Total weight of train, including engine, tons	532·2	553·2	526·2	553·2	572·2	576·2	(a) 398·2 (b) 541·2	(c) 542·2 (d) 418·2	(a) 418·2 (b) 542·2	(c) 541·2 (d) 418·2
Coal per mile, lb.	41·8	44·0	40·2	40·7	42·85	41·8	45·1		43·7	
Coal per D.H.P. hour, lb.	2·92	2·9	3·09	2·95	2·88	2·98	3·33		3·29	
Coal per ton-mile, including engine, excluding shed duties, lb.	·079	·080	·076	·074	·075	·0725	·091		·087	
Coal per sq. ft. of grate per hour, lb.	66·8	72·9	63·4	63·2	70·6	64·9	67·2		66·2	
Water, lb. per lb. of coal	8·45	8·5	8·47	8·33	8·66	8·37	7·9		7·64	
Lb. of water per D.H.P. hr.	24·6	24·7	26·2	24·6	24·93	24·9	26·7	25·6	25·7	24·7
Galls. per mile	35·2	37·4	34·1	33·9	37·1	35·0	35·0	36·0	32·5	34·3
Average speed, m.p.h.	49·8	51·7	49·1	48·3	51·4	48·42	48·0	45·3	48·4	46·0
Work done in H.P. hours	2022·3	2144·9	1839·5	1953·5	2105·6	1983·3	1339·9	1442·1	1299·3	1427·5

(a) Glasgow to Symington. (b) Symington to Carlisle. (c) Carlisle to Symington. (d) Symington to Glasgow.

boiler pressure. Dealing with the origin and performance of that engine, he said that a short time ago he had to consider the question of providing a much larger type of locomotive on the L.M.S. than any previously used. Had it been possible, he would have liked to have built a three-cylinder compound on the lines of those which had given and were giving such good service. Taking everything into consideration, it was decided to build a three-cylinder simple engine for a pressure which at that time was not being employed in this country, namely, 250 lb. per square inch. Particular attention was directed to the boiler proportions, which were finally settled largely by previous experience with an existing type. Although the engine had not yet been indicated, they had for a number of weeks past been making tests with a dynamometer car attached to various trains worked by the "Royal Scot" class of locomotive, and the results were so striking and consistent that he had thought it might be of interest to give the figures, as showing what was being done in this country with equal. It was difficult to make a comparison, but he would call attention to the fact that the consumption of coal and water per drawbar horse-power hour was as low as 2·66 lb. of coal and 22·3 lb. of water on the test between Crewe and Euston with the heaviest train tried. The only comparison he knew of with the locomotive dealt with in Mr. Fry's paper was obtainable from a publication by the Baldwin Company, in which the coal rate per drawbar horse-power hour was given as approximately 2¼ lb. at the middle of the working range. In the paper the figure for indicated horse-power hour was given at 2·6 lb., whilst the water consumption was much lower. In all these cases the question of coal consumed was of great importance. In the L.M.S. trials, as far as possible, the coal used was kept the same. The calorific value was about 14,050 B.Th.U.

Dr. R. T. Wagner, chief designer German State Railways, described at considerable length the 850 lb. pressure locomotive built by Schmidt's, of Cassel, and gave some particulars of its performance. As we hope in the course of a few weeks' time to publish a fully illustrated description of this engine, we do not propose to give Dr. Wagner's remarks in full. He stated that at 500 drawbar horse-power the engine had a coal consumption of 1·3 kilos. per D.B.H.P. hour, and at 1000 draw-bar horse-power a consumption of 1·05 kilos. on the same basis. The trials had shown that the locomotive was entirely useful (*sic*) on the road, and that it had an economy of 20 per cent. over ordinary engines of a similar power. While there were certain features of the design that would be modified in future examples, the chief troubles experienced were not in the major parts but in such details as the water-gauge glasses.

Mr. A. E. L. Chorlton asked why with the usual small ratio of expansion, say, 3 or 4 to 1, it was considered worth while to adopt compounding in a locomotive. Sir Henry Fowler's results showed that the simple engine was rather more economical than the compound. What were the limits in the locomotive which prevented the designer going to an expansion ratio of 10 to one? The "King George V." class of engine ran with expansion ratios up to 7 to one. If a locomotive could be run with such an expansion ratio why should it be kept down to 3½ to one? The Great Western engine had a larger cylinder capacity relatively to the boiler than the Royal Scot, and it was that fact which enabled it to run with seven expansions. What was the outlook in that connection for special types of valve gear, and, in particular, for separately driven inlet and exhaust valves with an expansion ratio of 10 to one?

Professor G. Lomonosoff said that it seemed that the application of superheated steam had ended the usefulness of compound locomotives. Nevertheless, the extremely interesting trials which Mr. Fry had described were a proof of the favourable results that could be reached by the combination of compounding and superheating, especially for heavy freight service. Unfortunately those trials were made only at slow speeds. With high speeds the results would have been less favourable, as had been proved by some Russian trials. Those trials were made in 1911–1915 and in 1925–1927 with four groups of equivalent locomotives:—

A.—Non-compound with saturated steam.
B.—Compound with saturated steam.
C.—Non-compound with superheated steam.
D.—Compound with superheated steam.

In addition, one of the locomotives of the last group had been tried with six combinations of cut-offs in small and big cylinders. The trials—the results are shown in Fig. 1—were made with speeds of from 25 to 330 revolutions per minute and therefore the influence of speed was made quite clear. First, the advantage gained by compounding fell sharply with the increase of speed. That was a result of the fluid resistance of the steam between the small and big cylinders. Secondly, the advantage of superheating increased with speed. That was a result of the high fluidity of the superheated steam, which decreased its fluid resistance. Thirdly, the decrease of heat transfer by compounding and superheating was practically the same. Therefore, as was demonstrated in 1897 by Querraux, for any two equivalent locomotives, compound and non-compound, there existed a critical speed, above which compounding was not advisable. According to the Russian trials that speed lay between 160–200 r.p.m. Express locomotives ran at 300–330 r.p.m., and hence for express service compound locomotives were not recommended.

Mr. E. C. Poultney said that he had always been in favour of the compound locomotive. Comparing the power, steam rates and speed of the engine dealt with in Mr. Fry's paper with corresponding figures obtained from a simple locomotive, he sketched on the board a diagram which we reproduce in Fig. 2. He said that in the compound engine the diagram showed that as the speed increased less steam was admitted to the cylinder per stroke. That fact, he held, spelt the throttling of the exhaust, and that in turn raised the question of the proportions of the steam passages. He was convinced that the passages in the engine dealt with by Mr. Fry ought to have been larger than they were, but he recognised that with piston valves it was very difficult to provide passages of the requisite area. One American railway, the Delaware and Hudson, was adopting poppet valves to get over the difficulty.

Mr. W. H. Patchell asked Mr. Fry to give more figures regarding the design of the boiler of the Baldwin locomotive. What was the boiler made of? Were the tubes of steel or nickel steel? He congratulated Mr. Fry on the figures which he gave for the heat performance of the boiler. The publication of such figures was all too rare.

Colonel H. A. Stenning asked Mr. Fry whether any trouble had been experienced with the tubes of the water-tube fire-box in the experimental locomotive. Very little trouble at that point, he said, would lead to disaster. Had the engine shown in service the performance indicated by the test results? The range of pressure from 250 lb. to 500 lb. was very interesting to those who were seeking to develop the use of high pressures such as 850 lb.

Mr. E. L. Diamond said that Mr. Fry's paper was notable as being one of the first in which an exact analysis of the cylinder losses in the locomotive engine

had been attempted. In previous discussions of the Altoona tests writers had generally been content to give the water rate curve and the cylinder thermal efficiencies. Mr. Fry, however, gave a number of reconstructed indicator diagrams enclosed within ideal expansion lines for the same quantity of cylinder feed at the pressure and temperature of the steam supplied to the engine. He believed he might claim to have published the first series of diagrams of that kind, which were due to the very careful tests of a three-cylinder compound locomotive which had been made under the President's supervision. But Mr. Fry quite rightly observed that his diagrams had the advantage of a direct measurement of the cylinder feed for every set of conditions represented, an experimental factor which it did not readily seem possible to incorporate in road tests. Mr. Fry had, however, chosen a rather unusual way of presenting his diagrams. In the first place, by using the exhaust pressure as the lower limit of his ideal cycle he entirely eliminated the back pressure loss from his analysis. His own (Mr. Diamond's) investigations had shown quite conclusively that in most locomotives that factor was the most serious source of loss in the engine, especially at high speeds. Further, with the best will in the world, one could not believe that the exhaust was so perfectly uniform and the point of compression so well defined as appeared from the reconstructed diagrams. An inspection of the specimen diagrams reproduced in the brochure relating to the engine published by the Baldwin Locomotive Works showed, in fact, that they were not so, and it was clear, therefore, that the author merely intended by his analysis to examine certain of the cylinder losses in detail rather than their practical effect on the efficiency of the engine as a whole. The author had further restricted his cycle of comparison by eliminating the loss due to incomplete expansion and forming his so-called "locomotive cycle." One appreciated his motives in thus attempting to hide the inefficiency of the old steam locomotive, and his own personal sentiments would lead him to join in the conspiracy. But as a standard of comparison the locomotive cycle had too many defects. In the first place, it varied for every diagram taken and was therefore no standard at all. Moreoever, it gave relative efficiencies that varied in a manner exactly opposite to the time variation. For instance, it was shown that as the cut-off was shortened the relative efficiency of the Baldwin engine, on the basis of the locomotive cycle, actually decreased from 87 to 80 per cent., although elsewhere it was made perfectly clear that the real efficiency increased to as great an extent, as one would expect. It was perhaps disappointing that while the author had studied in such detail the heat transference to the cylinder walls during admission, he had not estimated by means of a planimeter the total missing quantity during admission and expansion. That would perhaps have thrown some light on the surprising result that the heat transfer during admission increased with increase of speed. An inspection of the diagrams in Fig. 8 was sufficient to show that the heat loss during expansion decreased with increase of speed, as one had always been led to believe was the case. It seemed inconceivable that the heat transfer should behave in so contradictory a way during admission and expansion respectively. It should, however, be pointed out that it was in respect of that particular cylinder loss that stationary test plant results could not be regarded as a true index to conditions in the locomotive cylinder under actual running conditions. In the confined space of the testing building and in the absence of rushing wind the maximum cylinder temperature was bound to be in excess of that ever reached on the road; while in addition the steady conditions of a stationary test ensured that the mean cylinder temperature would closely approach that maximum, whereas on the road the fluctuating conditions would greatly vary the mean temperature. The extent of the effect of mean cylinder temperature on the loss due to heat transfer to the cylinder walls during expansion was clearly shown in the diagram reproduced here as Fig. 3. The two pairs of indicator diagrams there superimposed were taken under almost identical conditions of speed and cut-off; but the diagram showing the greater heat loss was taken soon after starting, while the other was taken after a long period of hard work ascending a bank. It might be observed that these diagrams showed the same characteristics as Mr. Fry's in that the steam remained superheated in the high-pressure cylinder and that the missing quantity assumed its chief importance in the low-pressure cylinders.

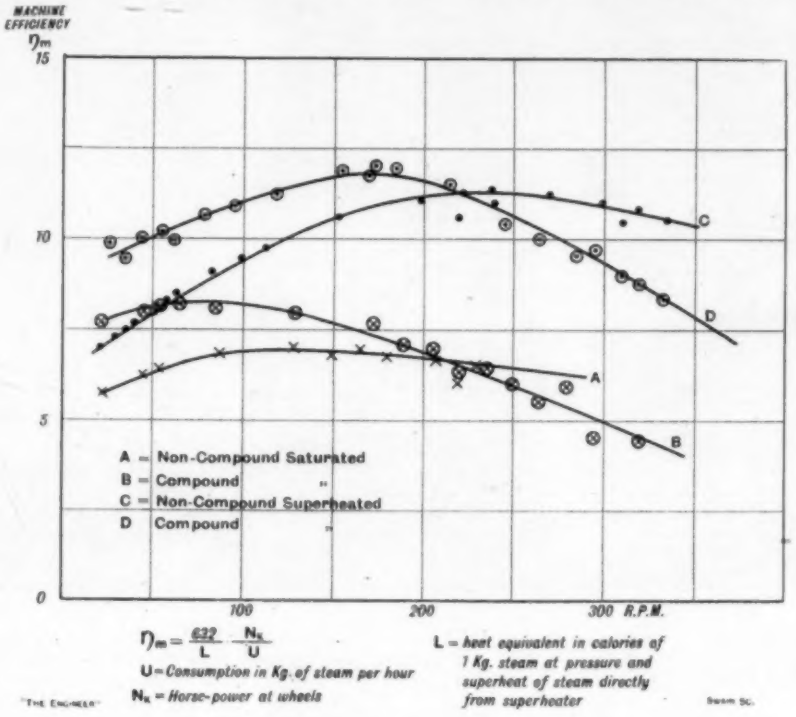


FIG. 1—TEST RESULTS OF RUSSIAN LOCOMOTIVES

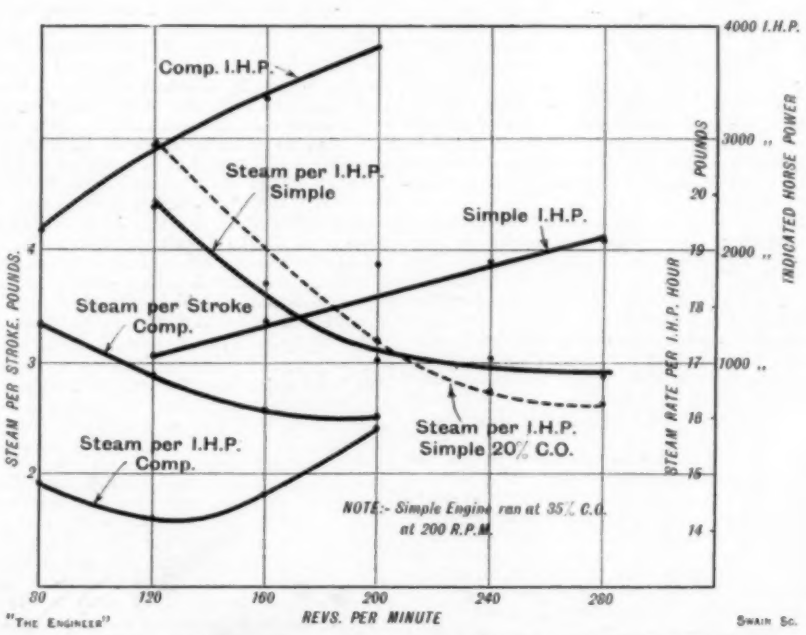


FIG. 2—POWER, STEAM RATES AND SPEED FOR COMPOUND AND SIMPLE EXPANSION

Compound .. .. 3 cylinders, 27" × 32" 70/40 C.O. per cent.
Simple .. .. .. 2 cylinders, 22" × 26" 30 C.O. per cent.

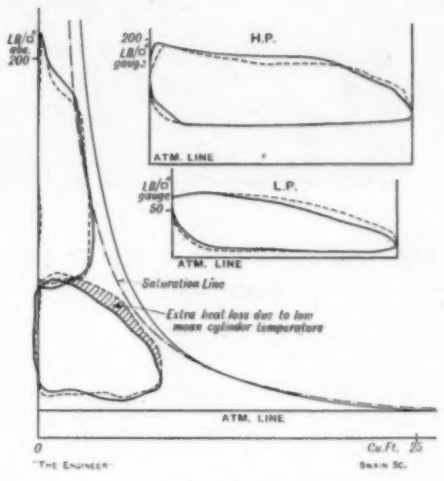


FIG. 3

Mr. Thomas Clarkson asked what was the method adopted for feeding the coal into the very long fire-box with which the Baldwin experimental locomotive was fitted. Mr. Fry replied that mechanical stokers were used.

There was no time for Mr. Fry to reply to the rest of the discussion.

The annual dinner of the Institution took place at the Connaught Rooms, Great Queen-street, on the evening of Thursday, December 15th, when H.R.H. the Duke of York, an honorary life member, was the principal guest. Over four hundred persons were present, and the chair was taken by the President, Sir Henry Fowler, who gave the loyal toasts.

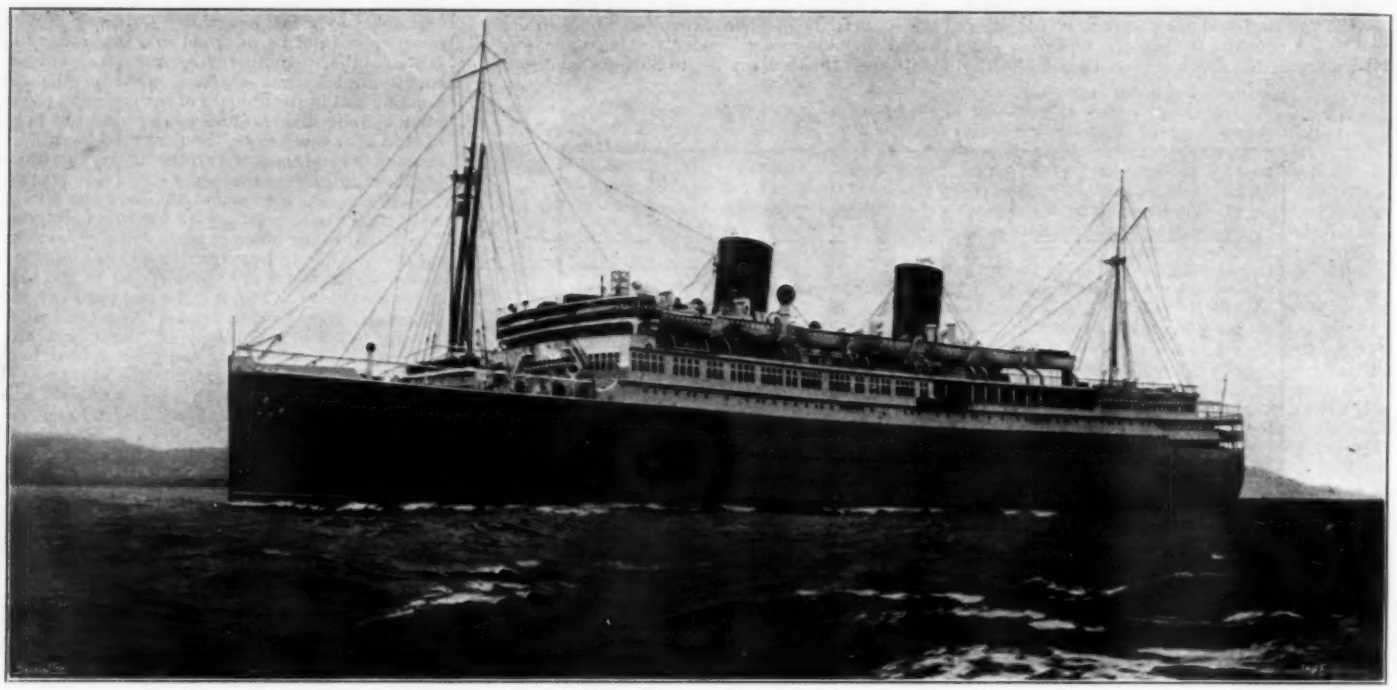
In proposing the toast of "The Institution of Mechanical Engineers," his Royal Highness made fitting reference to the important changes which had taken place in the forces of the Crown and civil aviation during the last twelve months. He expressed his pleasure that the new Director of Mechanisation at the War Office would be advised by a committee, the members of which were all corporate members of the Institution of Mechanical Engineers. His Royal Highness also stressed the importance of Empire travel, and the development of all methods of transport. In concluding his speech, he paid warm tribute to the work which had been done by the Institution in the training of young engineers and the granting of National Certificates. The President replied to this toast in suitable terms.

The toast of "His Majesty's Ministers" was ably proposed by Mr. Richard W. Allen, Vice-president, and response was made by the Right Hon. Neville Chamberlain, Minister of Health. In the course of his reply, Mr. Chamberlain stated that mechanical engineering was playing an increasingly important part in Local Government Board administration. As an instance of this, he went on to say that whereas in 1885 the expenditure of local authorities on engineering services amounted only to 12s. 8d. per head, in 1925 it had reached the sum of £3 15s. 6d. per head. Many problems of administration, he said, were bound up with the question of transport, and it was to the engineer that they looked for a solution of these problems.

The toast of "Our Visitors" was proposed in a happy way by Mr. William Reavall, past-President, and Lord Riddel replied in a speech full of humour, which brought to a close a very enjoyable evening.

THE QUADRUPLE-SCREW MOTOR PASSENGER LINER BERMUDA

WORKMAN, CLARK AND CO., LTD., BELFAST, BUILDERS



The Quadruple-Screw Motor Liner Bermuda.

No. I.

THE quadruple-screw motor liner Bermuda, which has a gross tonnage of close upon 20,000 and is propelled by the latest type of Doxford opposed-piston airless injection oil engines, is undoubtedly one of the outstanding motor vessels of the year. She was built by Workman, Clark and Co., Ltd., at Belfast, to special designs prepared by William Esplen, Son and Swainston, Ltd., of London, and to the order of the New York and West Indies Steamship Company, Ltd., of Hamilton, Bermuda, which firm is closely associated with Furness, Withy and Co., Ltd., of London. The service for which the new vessel has primarily been built is that between New York and the Bermuda Islands, which will be accomplished in a forty-hour Saturday to Monday trip, the return voyage to New York being made about mid-week. The accommodation is also arranged so that it is suitable for world cruises. It is expected that the Bermuda will make her maiden voyage from New York some time next month, for she has now completed successful trials on the Clyde and in the Irish Sea and recently left for New York.

Her early completion reflects much credit on her builders and engine constructors, for the order was only placed late in August last year, and the keel plate of the vessel was laid in mid-October of 1926. Although the coal strike seriously delayed the delivery of material in the early stages of the work, the ship was completed in sixteen months, compared with the more usual time of twenty-five to twenty-seven months which is generally allowed for such a vessel. Also, the engines, which were ordered from William Doxford and Son, Ltd., at the end of August, 1926, were delivered at the beginning of August, 1927, nearly a month ahead of the contract date.

GENERAL DESIGN.

As the accompanying view taken on trial shows, considerable care has been taken to produce a ship of pleasing and artistic external appearance. The lines of the Bermuda are clean cut, and with her greyhound bow, cruiser stern and balanced superstructure, her tall masts, and two large funnels, an impressive appearance is given. The principal dimensions of the hull and some machinery particulars are given below.

Hull Particulars.

Length overall	550ft.
Breadth moulded	74ft.
Depth moulded	45ft.
Service draught	24ft.
Gross tonnage	19,170
Designed speed	18 knots

Passenger and Cargo Accommodation.

First-class passengers	616
Second-class passengers	75
Crew	330
Cargo capacity	80,000 cubic feet
Refrigerated capacity	64,000 cubic feet

Propelling Machinery.

Number of screws	Four
Main propelling engines	Four
Type—Two-cycle, four-cylinder, Doxford, airless injection opposed-piston	
Total service output	11,200 S.H.P
Designed output each unit	2800 S.H.P.
Normal speed	110 r.p.m.
Maximum output each unit	3400 S.H.P.
Maximum speed	118-120 r.p.m.
Bore of cylinders	600 mm. (23⅝in.)
Upper piston stroke	760 mm. (30in.)
Lower piston stroke	1040 mm. (41in.)

Having in view the special service for which the Bermuda has been built, some interesting features were incorporated in her design. In order to keep down the swinging length the overall measurement along the water line was fixed at 547ft. Also, the normal draught of 24ft. was chosen so as to allow the ship to enter any of her ports of call. Exceptional strength has been obtained by the use of extra webs and stringers, so that the vessel may not only be able to weather heavy storms, but will also, it is stated, be quiet and free from vibration in a heavy seaway.

The safety precautions and the navigational equipment are also carried out on modern lines. International Convention rules as regards subdivision have been more than met, while as regards general construction the ship complies with Lloyd's requirements, the Shipping Laws of the United States, and the British Board of Trade Rules and Factory Acts. In addition, all the regulations which are imposed by the Panama and Suez Canal authorities have been met.

Brief reference may be made to the fire-detecting and extinguishing plant, which comprises a Lux-Rich smoke detecting cabinet with a CO_2 fire-fighting equipment, that works in conjunction with the detecting tubes, in addition to which hand extinguishers are arranged in various parts of the ship. The lifeboat installation is very complete and comprises eleven lifeboats with a motor lifeboat and two emergency boats along with a motor launch. One of the boats is fitted with Fleming hand propelling gear, and Marconi wireless equipment is also carried on some of the boats.

A feature of the hull design is the provision of through corridors and working passages for passenger and service use so that adequate covered interconnecting ways are provided throughout the whole of the ship. It may be mentioned that the cargo holds are furnished with large hatches of special design, so that motor cars can be carried without difficulty, while good embarking and disembarking entrances are also arranged, with appliances for rapid cargo handling. The steering gear is of an exceptionally powerful type and is electro-hydraulically operated, so that excellent manœuvring qualities will be given to the ship even in the confined waters of the Bermuda harbours. The deck auxiliaries, such as capstans, anchor, windlasses, winches, &c., are also specially constructed, and to them further reference will be made in a later article. A particularly complete compass equipment is carried, which includes Kelvin and McInnes Dobbie instruments, in addition to which there is a Sperry gyroscopic compass. A depth sounding and tonnage gauge installation of the Fox Instrument Company's pattern is also fitted.

PASSENGER ACCOMMODATION.

The first-class cabin accommodation includes a number of *de luxe* suites, which comprise a stateroom, bedroom, bathroom, and a private verandah. Cabin accommodation is provided of the single berth, and double berth type with a small number of three-berth cabins. From what has already been said it will be understood that an unusually high standard of comfort and elegance has been striven for in the decoration and furnishing of both the cabins and the public rooms. The greatest care and thought has evidently been expended on the artistic arrangement of furniture, the lighting and heating of cabins, and the hot and cold water services.

The accommodation and public rooms are grouped on seven decks, which embrace, besides decks A to F, the sun deck and the boat deck above it. All that has previously been said with regard to the high standard of cabin appointments applies equally, and probably more so, to the public rooms. They were decorated and furnished by Hampton and Sons, Ltd., of London, under the supervision of Mr. McInnes Gardner, of Glasgow, who is the consulting decorative architect for the owners.

The reception hall, which also serves as a *foyer* to the dining room, is on "C" deck and is decorated in Empire style. It measures some 70ft. in width by 35ft. and has a bureau at the after end with the purser's and chief steward's offices. If necessary, this room can be made to serve as an auxiliary dining room for a small number of extra passengers.

Electric lifts and staircases lead to the main dining room on "D" deck, which has a length of 110ft. with a width of 72ft. It is decorated in a modern adaptation of the Greek style, and the tables are provided for two, four, and six persons, are capable of seating over four hundred persons at one sitting. The ventilation and lighting have been carefully planned and the service arrangements are good.

The main group of first-class public rooms is on "A" deck, and chief among them is the social hall. This is an apartment planned on even more generous lines than the dining saloon before mentioned, having a length of 80ft. and a breadth of over 40ft. and extending in height through three decks. There is in it a balcony lounge, a cinema room, and a large proscenium with a stage complete with lighting equipment. The Georgian scheme of decoration has been carried out remarkably well and the room is ideal for entertainment purposes. Immediately forward of the social hall is the library and writing room, which is decorated in the Adam style. Aft of the reception hall on this deck there is the first-class smoking room, representing a fine example of Tudor treatment, with heavily moulded arches and mullioned windows with leaded lights and a timbered roof. The floor is laid with stone slabs of "Ruboleum," and the furnishings are strictly in keeping with the general scheme. Further aft is the Spanish Terrace Café, which leads down to an enclosed dancing space on the after deck. On the sun deck immediately above "A" deck is a further extensive dancing area aft, while this deck also gives access to the gymnasium and to a pleasingly designed observation lounge right forward, from which an extensive view can be obtained.

The second-class public rooms include a dining saloon on "D" deck with a reception hall and *foyer*, also a smoking lounge aft on "C" deck, this room being decorated in the Colonial Adam style. Excellent promenade space is reserved on "B" deck aft for the second-class passengers, while for the first-class passengers spacious promenades are to be found

both on the main promenade deck "A" and on the sun deck above. The "A" deck promenade is no less than 422ft. in length with a width of 11½ft., while that on the sun deck is 346ft. in length. There is thus ample provision made for walking, games, and dancing without mutual interference. As the upper decks referred to overhang the sides of the ship, maximum space for the use of the passengers has been obtained.

THE MAIN PROPELLING MACHINERY.

The main propelling machinery, which was built by William Doxford and Son, Ltd., of Sunderland, consists of four sets of engines arranged abreast and coupled direct to four screws. The general design of the Doxford engine is already familiar to our readers from previous descriptions, so that we need not dwell upon it in detail. There are, however, some interesting features in the particular design of engine which has been adopted for the Bermuda which warrants our especial attention. On page 712 two views of one of the main propelling units are reproduced, while in Fig. 1 we show sections through a main cylinder and also the scavenging pump. In the table previously given the principal sizes of the engine cylinders are set out. It is of interest to note that each engine, along with its fuel pump, fly-wheel and thrust block, weighs about 300 tons.

A point of special interest in these particular engines is the adoption of a reduced overall height, which has been made possible by using a 3 to 1 stroke-bore ratio and unequal strokes for the upper and the lower pistons. The latter course was taken in order to ensure that with a four-cylinder engine and cranks at right angles a good balance, both for the primary, vertical and the horizontal forces and couples and also for the secondary forces and couples, was obtained. By using a shorter stroke for the upper than for the lower pistons and making the strokes inversely proportional to the reciprocating weights the primary vertical forces and couples were compensated and eliminated. A slightly unbalanced revolving force remained to be corrected by making the centre crank pins hollow. Further, the secondary forces and the couples were balanced by arranging that the cylinder firing sequence was 1, 2, 4, 3, instead of the more usual 1, 3, 2, 4 order. Some additional balance for the scavenging pumps was required, which was obtained by adding balance weights to the crank webs. By doing so the forces were reduced to an unbalanced vertical secondary force of 1½ tons and a horizontal force of 7½ tons with the engine running at 120 r.p.m. It was considered that such forces were negligible for 300-ton engines. As a proof of this the engines were run on the test bed at 155 r.p.m. and each developed 4000 B.H.P.

The main crank shaft of the engine has thirteen throws, these including one centre throw and two throws for the side rods for each cylinder line, besides a single throw for the scavenging pump. It measures 38ft. overall and weighs 38 tons, and it is made up of three pieces. One length is for the two forward cylinders and another for the two after cylinders, while these two lengths are coupled by the portion of the shaft forming the scavenge pump crank pin and webs. The main journals are each 17in. diameter and the crank pins 18¼in. diameter. Although the shaft is drilled for forced lubrication, the oil is not led through any coupling face or shrunk joint, but at these points it is carried by externally arranged oil pipes. A 28 to 32-ton tensile steel was used for the crank shaft, which runs in six spherical bearings, and the same type of bearing was adopted for the big ends, so that a slight deflection is allowed for. It is of interest to mention the bearing pressures which are employed, as they are of the order of those in general use in marine steam engine practice. The figures given by the makers are for the crosshead pins, 1100 lb. per square inch; for the crank pins, 650 lb.; for the centre guide shoes, 30 lb.; and for the side guide shoes, 50 lb. per square inch. The main bearings carry only the dead load of the running parts and the pressure on them is about 100 lb. per square inch. The engine columns are so designed that the two half crank shafts already referred to can be lifted out by removing the two columns in front of the section, without disturbing any other parts of the main framing.

By referring to the left-hand view in Fig. 1, the general arrangement of the cylinder liners and pistons

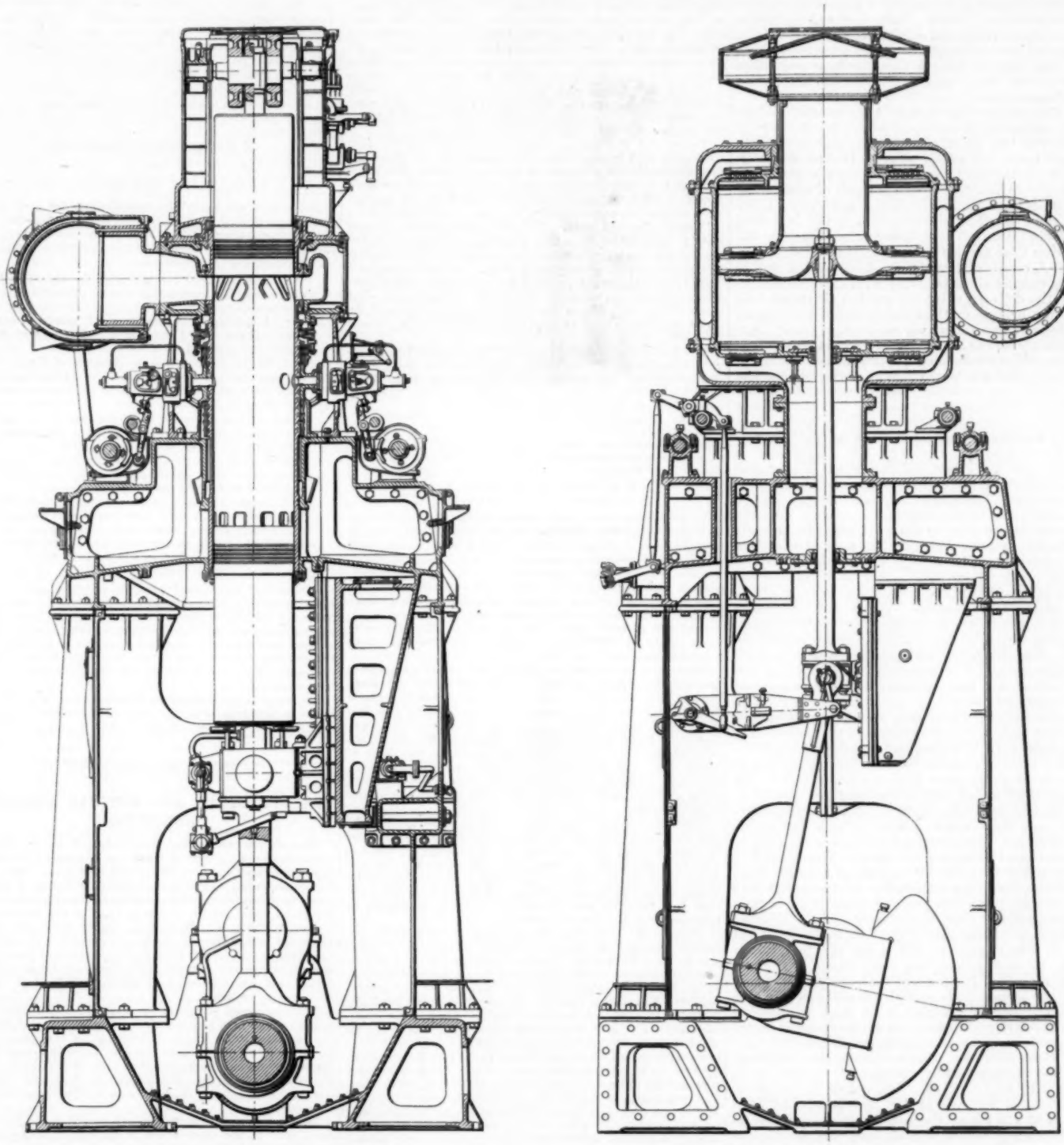


FIG. 1—MAIN ENGINE SECTIONS

may be seen. Completely machined liners made of special cast iron are employed, all ports being cut out from the solid, and the bars between the exhaust ports are drilled for the passage of cooling water. As the liner has a wall thickness of 1in. only, it is supported in the way of the combustion spaces by a cast steel jacket and forged steel shrunk-on rings. The steel jacket serves to house the valves, of which there are two fuel valves, a non-return air starting valve, a relief valve, and an indicator valve. All the valves are placed on the centre line of the combustion space. As is well known, combustion takes place between the hollow faces of the two pistons, which on the inner centre, when 2in. apart, form a deep and enclosed elliptical shaped combustion space. The piston heads are made of forged steel, as they are maintained at a high temperature. Each piston is fitted with five cast iron piston rings, and special provision is made to prolong the life of the rings and the liner by making piston ring grooves with a hard wearing renewable surface on the outer side and a flexible sealing lip on the inner edge.

The right-hand view in Fig. 1 shows the double-acting scavenging air pump, which is placed centrally between the two pairs of cylinders and is directly operated from the crank shaft. It has a piston diameter of 1580 mm., or 62¼in., with a stroke of 880 mm., or 34⅝in. The piston is made of manganese bronze with bronze disc valves and aluminium valve guards, and an aluminium suction trunk is bolted to the main piston. The delivery valves are of multi-ported disc type similar to the suction valves on the piston. A silent suction is obtained by the use of specially shaped silencers lined with "Mascolite."

From the delivery valve the suction air passes into the column bridges or the entablature of the engine, which forms a continuous air receiver, in direct communication with the lower ring of ports in all the four cylinders. The scavenging process is as follows:—At the end of the outward stroke of the pistons the upper piston uncovers the exhaust ports and allows the products of combustion to escape into the exhaust manifold, the lower piston then uncovers the scavenging ports and scavenging takes place on the "uniflow principle." A pressure of 2 lb. per square inch is employed and the swept volume of the scavenging pump is about 30 per cent. in excess of that of the main cylinders. Turbulence is obtained by giving the entering air a slight rotary motion.

We need hardly refer to the fuel pump, for the airless injection system, which will be seen at the after end of the engine, Fig. 2, page 712, and is gear driven from the crank shaft. The power absorbed by the pump is about 20 B.H.P., or nearly 7 per cent. of the power of the main engines. Hand and emergency governor controls are fitted and are operated from the control station situated at the forward end of the engine. A common rail fuel delivery system is used. Two duplicates of the main fuel pump, which are motor driven, are also arranged at the forward end of the engine-room.

The starting controls already referred to are neatly grouped at each end and are seen in the lower view Fig. 3, page 712. There are two cam shafts, one at the front and the other at the back of the engine, which are driven by bevel gears from the crank shaft. On the front shaft ahead and astern cams are provided, which can be brought into position by sliding the shaft, but the cam shaft which works the back fuel valves is non-sliding, as when running astern ample power is obtained from the front fuel valves. The front cam shaft is made to slide by operating a large hand lever to the right of the attendant. A large hand wheel serves to start up and control the speed of the engine, and automatically puts four cylinders on air, then on fuel, and controls the lifts of the fuel valves until full power is developed. At full speed the fuel valves open at 25 deg. before the dead centre and close 25 deg. after it. The compression pressure is about 285 lb. per square inch and the maximum pressure 570 lb., the engine working on a dual combustion cycle which is partly under constant volume and partly under constant pressure conditions. It may be mentioned that when on trial at the engine builders' works the engines, when running at an output of 2800 B.H.P. at 110 r.p.m., had a fuel consumption of 0·385 lb. of fuel per B.H.P. per hour. At 3400 B.H.P. and 118 r.p.m. the consumption increased to 0·395 lb., while under normal load the mechanical efficiency was almost exactly 90 per cent.

Our illustration Fig. 2, page 712, clearly shows the thrust block and turning gear. In a later article we shall refer to the trial results and also the arrangement of the machinery in the vessel and some of the electrically operated auxiliaries.

(To be continued.)

The New Ford Car.

(By a Correspondent.)

THE motor industry is now one of the most important engineering industries of the world. Whether we take the total power of the engines produced, the value of the output, or the effects on social life, it is pretty clear that the petrol-driven motor car and its descendants are the most important engineering product of modern times. Of this industry Mr. Henry Ford is obviously the outstanding personality, and anything he produces is therefore of great interest.

For many years Mr. Ford has been identified in most people's minds with what is known as the "Ford" car, which is too well known to need description. This is, of course, not the only type of car that he has produced. In his earlier days he built various models, some of them large six-cylinder cars, but they were by no means entirely successful. About 1908, however, the model T was placed on the market, and was very soon an established success. It soon took a commanding lead over any other car in the matter of numbers sold, and held that position without challenge until the last year or so. The enormous extent of his industry will be realised from the fact that over 1¾ million cars of Model T have been produced in a single year in America, while the foreign Ford factories turned out nearly 200,000. The total yearly production was therefore nearly 2 million, and the brake horse-power some 40 million. The profits were 20 millions sterling per annum. This is a colossal industry for one single firm to have built up on the output of a single article, and we do not realise in this country in the least either its extent or the benefit that the car has been to other countries. Our legislators have rated motor cars on a system of taxation which taxes the Ford car more highly than many others, which are far heavier, more powerful and faster, and have, by so doing, practically killed it in this country. We do not, therefore, either get the advantage of its production here, nor do our industries get the benefit of its use like other countries.

The model T Ford is unique, not only from the fact that it is sold in such enormous numbers, but from the fact that it is the only car of any importance which has remained on the market practically unaltered for over nineteen years. Changes have been made in the appearance of the bonnet, radiator, &c., but very little indeed in the mechanical part. Probably the car which most nearly approaches it in this respect is the 40–50 Rolls-Royce, but the latter has undergone changes in the number of speeds and arrangement of springs. Other makers have been frequently urged in print to leave their designs unaltered, and concentrate on cheap manufacture, but most designs of fifteen to twenty years ago would be quite unsaleable now at any price for which they could be made.

The fact is that the Ford car has depended for its success on its design to a very much greater extent than most people realise. The designer had evidently a quite clear-cut idea of what he wanted to produce—which is rather rare—and was very skilful in producing it.

To be successful, the car had to be:—

Light for the weight it would carry.
Simple to operate.
Easy to repair.
Capable of standing rough usage.
Cheap to produce.

In all these points the Ford stands out from other cars. It is the lightest car with a real five-seated body that is now made, and probably lighter than any car at any price which would carry the same load and stand the same rough usage. Its two-speed epicyclic drive is easy to manipulate and fairly "fool-proof." The engine, with its detachable head, is easy to get at for repair. Having large cylinders and running at moderate speed, it is light for its power and neither engine nor transmission is subject to wear owing to high speed. Further, it is very cheap to manufacture.

The latter is a most important and often a neglected feature of design. Anyone who will study the Ford chassis and compare it with most contemporary designs can see at once the enormously greater thought that has been spent on the design in eliminating expense of manufacture. Many of the features which facilitated cheap production—*e.g.*, unit engine and gear-box, top half of crank case cast with engine, detachable cylinder head, &c.—have become common practice, but no car appears to be so thoroughly designed for cheap production as the Model T Ford.

However, it has been quite clear in America for the last year or more that the wonderful run of this model has come to an end, and that its popularity is waning. The fact seems to be that price has ceased to be the dominating factor, and the large bulk of the buying public wants something better even at a higher price, and such cars as Chevrolet and Dodge have been increasing in popularity at Mr. Ford's expense.

Accordingly, Mr. Ford has produced a completely new model, descriptions of which are now made public. Without going into details, it seems that the new Ford, in place of being of a very distinctive design like the old one, is, generally speaking, very conventional in its general lay-out. The engine has four cylinders, 3¾ by 4¼, having a cylinder capacity of 200 cubic inches (3300 cubic centimetres). It is of the moderate speed type and develops 40 B.H.P. at 2200 revolutions per minute. These dimensions are conventional, the Dodge having cylinders, 3⅛in. by 4½in. and the Chevrolet 3 7/16in. by 4in. A special model with smaller cylinders is to be made for the English market. The transmission also is conventional, having a multiple disc clutch and three-speed sliding gear. In fact, the only features which are really at all unconventional are the springs, which are still of the cross type, generally similar to those of the Model T. The new car is fitted with four-wheel brakes, Hondaile shock absorbers and wire wheels. The prices in the United States are said to be:—Two-seater, 385 dollars (£77); two-door saloon, 495 dollars (£99); four-door saloon, 570 dollars (£114). These prices are extraordinarily low, considering that there appears to be nothing special in the design to make it very cheap to manufacture. The nearest competitor appears to be the Chevrolet, which is generally of very similar size and of conventional lay-out. The price of the Chevrolet with two-door saloon is 595 dollars, or 100 dollars (£21) more than the new Ford, and this does not include four-wheel brakes. General Motors, which make the Chevrolet, have very well organised works, and an output of several thousand cars a day, and if Mr. Ford can sell his new car at the suggested prices and make a profit, he will have performed a very remarkable feat. He is said to be making plans to produce, if necessary, 12,000 cars a day.

As mentioned, the English system of taxation has caused Mr. Ford to put on the market a special model for use here. It will be manufactured in the English works. It is generally similar to the ordinary model, but has cylinders 3in. diameter in place of 3¾in., the capacity therefore being 120 cubic inches (2000 cubic centimetres). The horse-power is stated to be 28 B.H.P. at 2600 revolutions, but there seems no reason why the engine should not be run faster than this, and be made to give about as much power as the larger cylinders, if the valves are the same size. The effects of the purely artificial method of rating vehicles for taxation in this country are very evident here. There can be no question that the car with the larger engine will be in every way the better car. The engine will give the same power at less than two-thirds of the revolutions, and therefore internal friction and wear and tear will be much less, while noise will also be greatly reduced. It may be taken for granted that no one outside England will buy the model with the small cylinders when they can get one with the larger size from America or Canada. Having no hope of exports, Mr. Ford can only expect a small output from his factory here, and with a small output costs are relatively high. Accordingly, we find that the prices announced for this model are:—Touring car, £150; two-door saloon, £185; four-door saloon, £215; these prices being some 80 per cent. or more above those in the United States. Even at these prices it will be distinctly the cheapest car with a really full-sized five-seated body sold here.

B.E.S.A. SPECIFICATIONS.

STEEL BARS FOR MACHINING.

A REVISED edition of the Specification for Steel Bars in the Production of Machined Parts has just been issued by the British Engineering Standards Association. The principal alterations embodied in the 1927 edition of this specification are as follows:—

1. The Bessemer Basic process for the manufacture of the steel has been eliminated and the electric process has been included.

2. A minimum carbon content has been specified for Grades 1 and 2 steels and omitted from Grade 3 (free cutting) steel.

3. The minimum tensile strength of Grade 3 (free cutting) steel has been reduced to 28 tons per square inch for bright bars, and to 26 tons per square inch for other finishes.

In all three grades provision has been made for the higher percentage elongations obtainable from other than cold rolled and drawn bars.

4. Round bars above 5in. diameter and square bars above 5in. width across flats have been standardised in definite steps of ¼in.

5. Bright hexagon bars corresponding to Numbers 1, 2, 3 and 4 B.A. bolt sizes have been included, and the hexagon bars corresponding to ⅜in., ⅞in. and 1¼in. bolt sizes have been omitted as these three sizes are no longer included in the British Standard Whitworth and British Standard Fine Screw Thread Tables.

It has not been found practicable to include standard tolerances for the black bars in view of the differing purposes for which the bars are used, *e.g.*, tolerances which are commercially suitable for bars for the direct production of machined parts are regarded as too wide for the production of bright drawn bars from the black rolled material. For a similar reason standard tolerances for blue bars have been omitted.

Copies of this revised Specification (No. 32, 1927) may be obtained from the B.E.S.A. Publications Dept., 28, Victoria-street, London, S.W. 1, price 2s. 2d. post free.

THE PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.

THE eighteenth annual Exhibition of the Physical and Optical Societies will be held on Tuesday, Wednesday and Thursday, January 10th, 11th and 12th, 1928, at the Imperial College of Science and Technology, Imperial Institute-road, South Kensington, and will be open in the afternoon from 3 p.m. to 6 p.m., and in the evening from 7 p.m. to 10 p.m. More than eighty firms are, we are informed, exhibiting in the Trade Section this year, and, in addition, there will be a group of research and experimental exhibits by Fellows of the Societies, research laboratories and institutions, and others. Historical exhibits will also be included.

The discourses in connection with the Exhibition, which will be given at 8 p.m. on each evening, are as follows:—(*a*) January 10th, Mr. A. Whittaker, of the Gramophone Company, Ltd., "Progress in the Recording and Reproduction of Sound"; (*b*) January 11th, Mr. V. E. A. Pullin, F. Inst. P., "Recent Application of X-Rays"; and (*c*) January 12th, Dr. J. W. T. Walsh, F. Inst. P., "Artificial Daylight."

We understand that invitations to the Exhibition have been sent to the Institution of Electrical Engineers, the Institution of Mechanical Engineers, the Royal Aeronautical Society, the Royal Meteorological Society, the Faraday Society, and a number of other societies and bodies. As in previous years members of these societies should apply for tickets to their secretaries. Others may obtain tickets on application to the secretary, the Physical and Optical Societies, 1, Lowther-gardens, Exhibition-road, London, S.W. 7. Tickets are required only on January 10th and 11th. Admission on the third day, January 12th, will be without ticket.

IN view of the interest aroused by the recent demonstrations of the Ajax-Northrup furnace, an account of which is contained in our issue of December 9th, it may be of interest to our readers to know that a small furnace of this type, which was presented to the Science Museum, South Kensington, London, in 1924 by Campbell and Gifford, Ltd., is on exhibition in the Metallurgy Gallery. The furnace has been sectioned in order to show the insulating lining and the flattened copper coil which carries the primary current.

Railway Matters.

THE future of the company-owned railways of Burma has been decided. The Under-Secretary for India, answering a question in the House of Commons on December 13th, said that the recommendation of the Government of India had been accepted and the railways of Burma would be transferred to State management after December 31st, 1928.

ACCORDING to an answer made to a question in the House of Commons, the Government of India has purchased, for the sum of 20 lakhs of rupees, the works of the Peninsula Locomotive Company, and intends to use them for the manufacture of carriage underframes. Earl Winterton added that so far as he was aware there was no intention to build locomotives and wagons there.

AT the level crossings of public roads over light railways the requirements as to the provision of gates, gatekeeper and lodge, as found on standard lines, may be modified with the consent of the Ministry of Transport. At a certain level crossing on the Basingstoke and Alton Light Railway gates have been provided, and notice has now been given by the Southern Railway Company that it is applying for an Order to dispense with the gates and to provide a cattle guard instead.

THE "Proceedings" of the Institution of Railway Signal Engineers for the second part of the session 1926–27 is of interest to the general public, and particularly to motorists, because of the instructive paper on "Railway Level Crossings," by Mr. F. Horler. There is also a very full description of the light signalling installed on the Southern Railway. Copies of the report, 7s. 6d. each, may be obtained from the secretary, Mr. M. G. Tweedie, 80, Caversham-road, Reading, Berks.

ANSWERING a question recently as to Charing Cross Bridge, Colonel Wilfrid Ashley said that the examination of the scheme of the Royal Commission for a double-decker road and railway bridge at Charing Cross was for the present directed primarily to its engineering and financial aspects. The problem was one of great difficulty and complexity, and although all possible progress was being made, he did not anticipate that the engineers charged with the investigation would be in a position to report before next spring.

THE Court of Appeal, on December 16th, dismissed the appeals of the Southern Railway and the East Kent Railway against the sanction given by the Railway and Canal Commission for the Tilmanstone Ropeway. The question hinged on whether, as urged by the railway companies, the ropeway was for marketing or whether it was for working the coal. The latter had been sanctioned as an early auxiliary right and the judgment of the Court of Appeal was that the colliery company was entitled to the powers objected to by the railway companies.

A PORTER on the Southern Railway was killed at Cannon-street Station last summer by being pulled on to the line and run over, through the sleeve of his coat being caught by a door handle. The case was inquired into by Mr. Main, the senior assistant inspecting officer, whose report contains the interesting information that the views of the staff generally were being taken as to the most desirable form of handle to employ. Mr. Main added that a suggestion was before the railway company with regard to the advisability of slitting up the coat sleeves of platform staff so as to lessen the liability of handles being caught therein.

IN an interview given to some newspaper representatives on December 9th Sir Ralph Wedgwood gave some interesting details as to the marshalling yard at Whitemoor, near March, which was described in this column on February 2nd last. There will be ten reception roads, each capable of accommodating a train of eighty wagons, and the wagons will be sorted by the hump process into forty sorting sidings having an aggregate capacity of 3679 wagons. What will be quite novel in this country will be the provision of the Frolich car retarder, as used in Germany, which is a form of side brake that rubs against the side of the wheels of the wagon as it enters the sorting sidings and checks it instead of that being done by a shunter with the hand brake of the wagon.

THE report by Lieut.-Colonel Mount on the collision of September 19th between a passenger train and a goods train that was leaving Plaistow sidings shows that the accident was due to the very unusual cause of the driver of the passenger train seeing some way ahead of him the starting signal at Plaistow in the "off" position. Not knowing that the signal was for the goods train, he took it as his and kept on steam, and overlooked the intervening starting signal at West Ham and the home signal at Plaistow, which were against him. Colonel Mount recommends that the height of the signals concerned be reconsidered, and that Rule 40 should be made operative at West Ham—the latter would have kept West Ham home signal at "danger," which signal the driver actually saw. It is also observed that automatic train control would have prevented the collision.

ACCORDING to the Board of Trade returns the value of the railway material exported during the first ten months of the present year was as follows, the corresponding figures for 1926 and 1925 being added in brackets:—Locomotives, £1,726,352 (£2,832,817, £2,246,936); rails, £2,767,776 (£1,317,374, £1,614,662); carriages, £2,601,242 (£2,310,875, £1,253,056); wagons, £2,408,289 (£2,522,656, £2,978,399); wheels and axles, £637,304 (£387,001, £498,693); tires and axles, £561,798 (£243,280, £369,410); chairs and metal sleepers, £1,178,548 (£624,029, £842,715); miscellaneous permanent way, £1,252,263 (£926,642, £1,189,943); total permanent way, £6,624,741 (£3,651,508, £4,684,404). The weight of the rails exported was 335,985 tons (162,658 tons, 172,989 tons), and of the chairs and metal sleepers, 118,970 tons (64,212 tons, 76,259 tons). During the month of October last alone the value of the locomotives sent overseas was £262,340, and included:—The Argentine, £40,886; Straits Settlements, £24,982; Australia, £21,690; India, £17,446; Ceylon, £11,880 and other countries than the Argentine in South America, £11,404. During the same month the value of the rails exported was £412,830, and included:—India, £160,371; the Argentine, £64,441; Portuguese East Africa, £31,169; British West Africa, £30,871; South Africa, £21,386; Australia, £9900,

Notes and Memoranda.

FIVE large coal seams have been discovered to run right across the site selected for residential quarters of the Telfess mining region in Siberia.

WORKS have been acquired at Inchinan, near Renfrew, for the manufacture of the India pneumatic tire. It is intended to produce 1000 tons a day.

VALUABLE deposits of iron ore are said to have been discovered at Springfield, Antigonish County, Nova Scotia, where extensive drilling operations are being carried on.

IT is stated that new plant for the concentration of North African phosphate is shortly to be erected by the Gafsa concern, which controls vast deposits of lower-grade material.

WHAT is said to be one of the largest fireclay deposits on the British Columbia coast, situated near Hillbank, on the line of the Esquimalt and Nanaimo Railway, is being developed.

THE exports of soda ash from the Magadi deposits of British East Africa have increased to 25,547 tons for the first half of this year, as compared with 19,427 for the whole of last year.

ONE of the latest types of motor omnibuses put into service in Western America is capable of seating eighty-two passengers. It is driven by two six-cylinder engines, one for each driving wheel, so that no differential gear is necessary.

AT Bellows Falls, Vermont, New England, there used to be some seventy-five water wheels ranging in output from 50 to 500 horse-power; but they have become obsolescent. A new scheme of development of the water power involves the installation of three 20,000 horse-power turbines and the electrification of the old mills which were originally supplied directly by water power.

IN the latest official report on the trade of East Africa it is stated, with regard to iron and steel manufactures, that "earlier reports mentioned the heavy increase in competition from German sources of supply, but that increase has not been maintained. It was largely occasioned by offers of long credit from that quarter in an endeavour to stimulate the reintroduction of foreign supplies, but, largely owing to the decrease in offers of long credit, the rising price index of German manufacturers, the impossibility in many cases of obtaining firm offers of delivery and more than all the fact of continually increasing replacement prices, Great Britain has regained some of the market which was lost."

WHEN all visible chinks are closed in a room, a fire burns no less well and some 20,000 cubic feet of air an hour continues to pass up the chimney. In a dug-out of 900 cubic feet capacity, containing thirty soldiers and three candles alight, Professor Leonard Hill found that natural ventilation on a cold day maintained a flow of air ample enough to secure chemical purity, in spite of double anti-gas curtains set to block the two exits. Mr. T. Crowder estimated that there is a sum total of about 500 lineal feet of crevices at the edges of doors and windows in a sleeping railway car. If these averaged one-fiftieth of an inch in width and admitted air at half the rate of the train speed, 40,000 cubic feet of ventilation would be more than accounted for.

IN keeping with its wonted attitude of open-mindedness and receptivity to new ideas, the Rand mining industry has, according to the *S.A. Mining and Engineering Journal*, recently been considering the possibility of applying the ancient practice of fire-setting, in a new form, to the breaking of rock underground. The suggestion submitted to the mines is a development of the German "flammenwerfer" used in the Great War. This machine, somewhat like a giant blow-lamp using paraffin as fuel, on the principle of the Primus stove, produces a flame from 3ft. to 6ft. long, 6in. wide and 1in. thick at the point of delivery at the face. This flame is said to develop a temperature of from 1000 deg. to 1500 deg. Cent. The effect is to cause rapid expansion of the rock face accompanied by a process of flaking off.

THE new bridge across the Sautet Gorge of the Drac River, in the French Alps, is to be a single reinforced concrete arch of 283ft. span, 525ft. above the bottom. The centering at such a height was a difficult problem, but it was solved by the engineer, Monsieur Caquot. The solution was to span the gorge with a three-hinged arch of wood construction, each half to be erected in a vertical position at either side and then rotated about the lower ends as pivots until the outer ends would meet in the middle, these two half-arches to be so shaped that, when in position, the upper chord would coincide with the curve of the intrados of the concrete arch, and thus act as a base for the forms. The construction of one of the abutments was completed not long ago, and very recently the placing of this unusual centering was successfully completed. The actual lowering of the two halves into position was accomplished in forty-five minutes.

IN the course of a paper on the oil pollution of seas, read before the Chemical Engineering Group, Mr. C. S. Garland said that large oil-using ships will pump from 1000 to 2000 tons of ballast water at the end of each voyage, and this will normally be carried in tanks of up to 200 or 250 tons capacity. The average content of oil in each tank will be from 2 to 3 per cent., and the bulk of this—probably 95 per cent.—will be floating on the top of the water, and will be discharged in a body when the bottom of the tanks is reached. It has been demonstrated that this 95 per cent. of the oil is in masses averaging more than 0·2 mm. in diameter, which will rise to the surface of the mixture, if eddy currents are avoided, in from one to two minutes. The balance of 5 per cent. or so of the oil can be divided into two forms, which the American Bureau of Standards has designated as "suspended" and "emulsified" oil. The suspended oil, consisting of particles of from 0·01 mm. to 0·2 mm. in diameter, which will settle out in water free from disturbing currents in two to four hours. There remains a small quantity—0·1 to 0·5 per cent.—of oil in a truly emulsified form, which is still completely dispersed in the water even after months of standing in a quiet condition.

Miscellanea.

IT is proposed to erect a linoleum factory at Auburn, near Sydney, Australia, at a cost of about £250,000.

IT is proposed to put up a plant for the manufacture of aluminium at Bell Bay, Tasmania. The first unit is to cost £200,000.

THE nitrogen fixation plant of Synthetic Ammonia and Nitrates, Ltd., at Billingham, is to be extended by the addition of two new units capable of producing 50,000 tons of nitrogen per year each.

THE fourth unit, of 28,000 horse-power, at the Great Falls power plant of the Manitoba Power Company, is about to be put in operation, and preparations are being made for two more units of 40,000 horse-power each.

IT is understood that tenders are to be asked in January by the Swedish-American Line for the construction of a third new motor liner. The new ship will have a length of 608ft., a width of 78ft., and a gross tonnage of 21,000.

THE experiments which have already been made by the Fuel Research Board on the production of liquid fuels from straw and waste vegetable materials have proved so successful that they are to be continued on a larger scale.

FIVE arches of High Bridge, which carries the old Croton aqueduct over the Harlem River, New York, are being demolished, and replaced by a steel span to improve the navigation facilities on the river. The bridge was begun in 1839 and took nine years to build.

ACCORDING to a message from Haifa, Jerusalem, a start will be made on the new harbour works at Haifa on May 1st. It is stated that the Admiralty will contribute £500,000 towards the cost of the works subject to a special extension being provided suitable as a warship anchorage.

THE general idea of the automatic sub-station has been adopted in the Rand Refinery, where some of the electrically operated plant is left to attend to itself for considerable periods, but where it is important that the process should be continuous. For this purpose the Allen West Company, of Brighton, has installed switching gear that automatically re-closes any circuit breakers which may open, and persists in doing so until it is obvious that the fault cannot be cleared. When this state of affairs continues an electrician must, of course, be called in to attend to matters.

ALTHOUGH there has been some delay in the construction of the new Nerbudda Bridge of the Great Indian Penninsula Railway, better progress is now being made. The bridge is to consist of six spans, each of 170ft. of steel lattice girders, supported on steel trestle piers and two spans each of 40ft. girders supported on masonry piers. The foundations are practically complete and the manufacture of 90 per cent. of the steelwork has been finished at the Mulund shops. It is expected that the building of the bridge will be sufficiently advanced to permit of the through route for traffic being opened next April.

SUBSTANTIAL progress in the development of the Post Office telephone system during September is recorded by the *Telegraph and Telephone Journal*. At the end of September the number of stations on the system was 1,566,960, an increase of 9571 during the month, 3482 of the latter being in London and 6089 in the provinces. The stations at work on September 30th were:—London, 553,264; England and Wales (excluding London), 849,745; Scotland, 144,037; Northern Ireland, 19,914. During August the inland trunk calls totalled 8,518,656, an increase of 1,023,560, or 13·7 per cent., compared with August last year.

IT is reported by the National Federation of Iron and Steel Manufacturers that the number of furnaces in blast at the end of November was 155, a net decrease of seven since the beginning of the month, ten furnaces having gone out of operation and three having been put into blast. The production of pig iron in November amounted to 575,900 tons, compared with 596,300 tons in October and 591,500 tons in September. The production includes 190,500 tons of hematite, 184,300 tons of basic, 152,200 tons of foundry, and 27,800 tons of forge pig iron. The production of steel ingots and castings amounted to 698,700 tons in November, compared with 699,000 tons in October and 777,000 tons in September.

ACCORDING to the *South African Mining and Engineering Journal*, among the latest ventures to be talked of locally is a proposal to manufacture paper from the extremely tough and fibrous grass which grows in such profusion in the Transkei districts. Laboratory experiments have proved most encouraging, and steps are now being taken to establish the undertaking on a commercial basis. It is not, of course, the first time that a papermaking industry has been started in South Africa, but previous efforts have been more particularly directed to the manufacture of brown wrapping paper, and although a first-class material was produced, it unfortunately failed to achieve the commercial success that the enterprise and patient persistence shown by its promoters in face of numerous difficulties deserved.

HARBOUR extensions and a new bridge over the Swan River at Fremantle, the port of Perth, W.A., and subsidiary works, at an estimated cost of £3,200,000, have, says the *Industrial Australian*, been recommended to the State Government by the Engineer-in-Chief, Mr. F. W. H. Stileman. He suggests the construction of a bridge for road and rail traffic at a point 1000ft. above the existing bridge over the Swan River at Fremantle, up to which the harbour works would be extended. He recommends also for construction at a later period, extensions to the north of the present harbour entrance, instead of above the proposed new bridge, as recommended by Sir George Buchanan. The bridge and approaches, including a railway from North Fremantle to Robb's Jetty, are estimated to cost £1,200,000. The extension of the harbour up to the new bridge, providing 5750ft. of additional quay, with equipment, making a total of 15,829ft., and dredging to a depth of 32ft. below low water, are estimated to cost £2,000,000. The present width of the harbour is 1400ft., with a depth of 36ft. below water level. Over the extension a depth of 32ft. is intended, and a gradual reduction of the width to 800ft. at the upper end.

MAIN ENGINES OF THE QUADRUPLE-SCREW MOTOR LINER BERMUDA

WILLIAM DOXFORD AND SONS, LTD., SUNDERLAND, ENGINEERS

(*For description see page* 708)

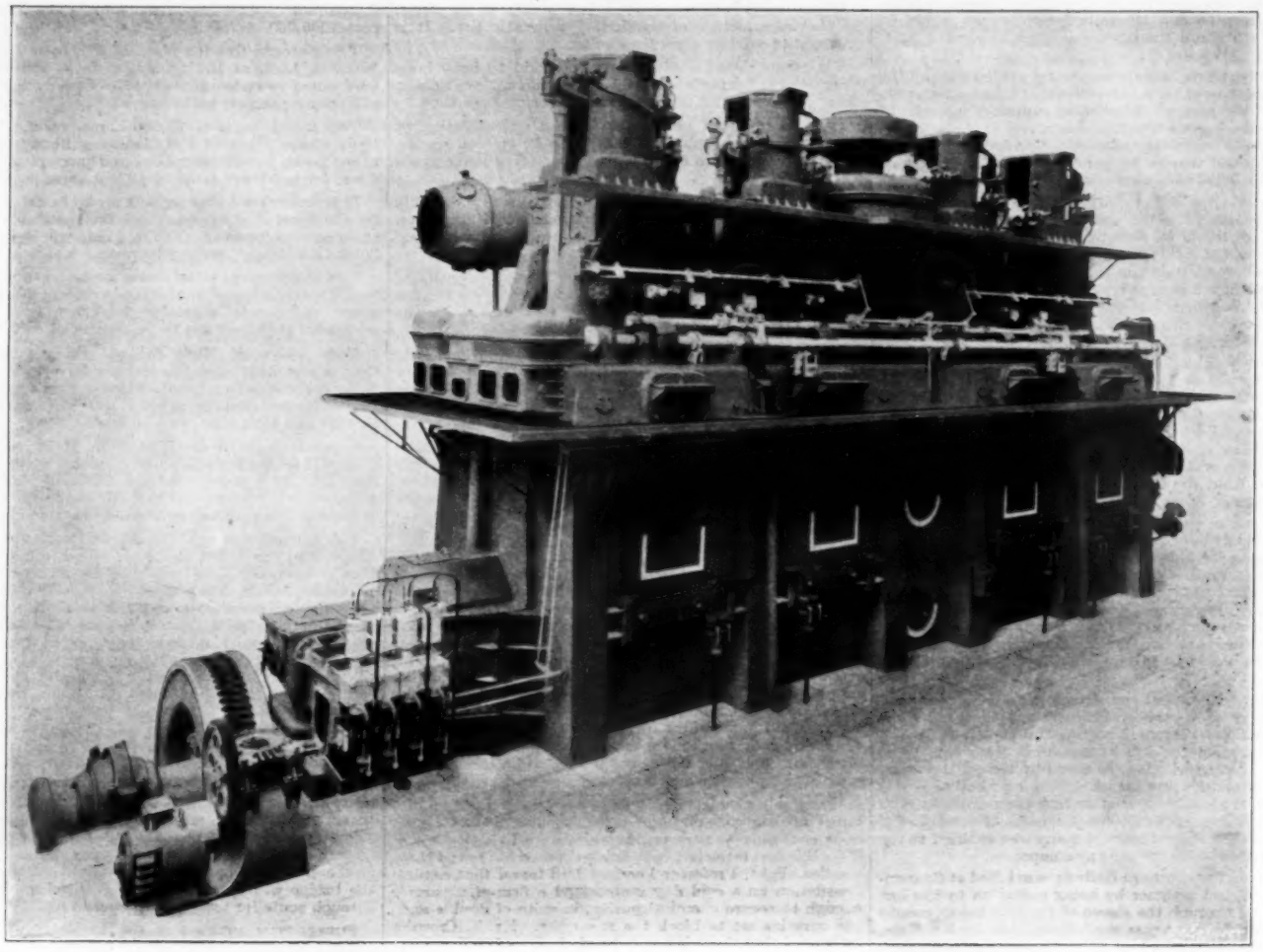


FIG. 2—AFTER END OF ENGINE SHOWING TURNING GEAR AND FUEL PUMPS

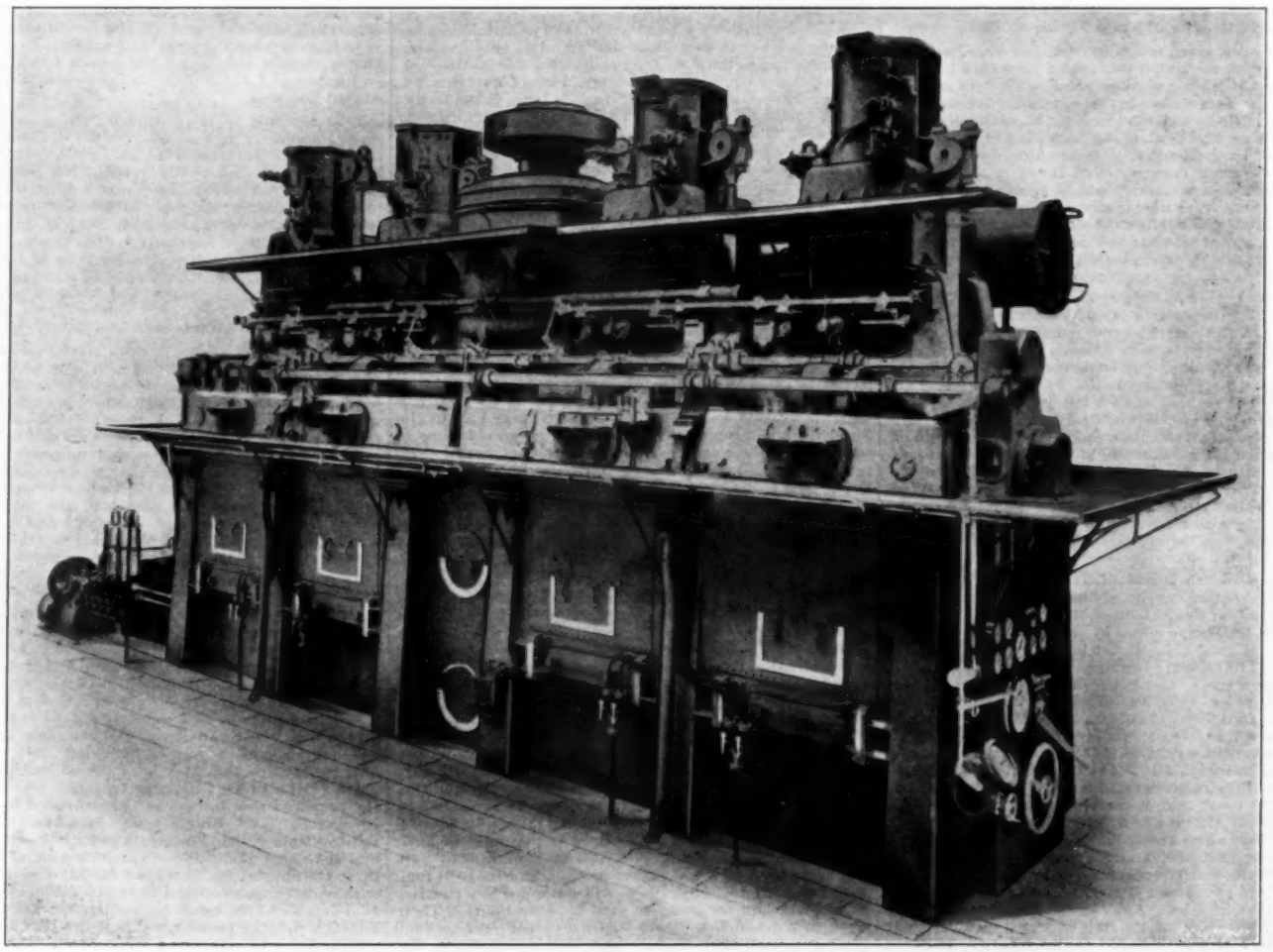


FIG. 3—VIEW SHOWING ENGINE CONTROLS AT FORWARD END

The Engineer

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THE ENGINEER.

DECEMBER 23, 1927.

Power Companies and Industrial Plants.

UNLESS an electricity undertaking can secure for itself the greater part of the industrial load within its area of supply it may be said to have failed in its primary function. Constituted as it is for the sole purpose of serving a district with electric energy, it should be able to sell power on terms which would attract the great majority of power users. There is something very unsatisfactory in the contemplation of a power company wanting load and yet unable to convince the factory managers that it would be to their advantage to take power from the mains. That, however, is a very common state of affairs. It exists, indeed, to a greater or less degree in every industrial area of the country. If any individual factory is considered, the question as to whether it could produce its own power cheaper than it could purchase from outside is one to which a definite answer should always be possible. One may go even further and say that the amount of money which would be saved or lost annually by buying power at a given price per unit can usually be stated with as much accuracy as is attainable in any other engineering estimate. Why, then, is there room for so much argument? If we leave out of consideration the small number of cases in which, for reasons of sentiment or of fancied greater security, the factory manager decides to maintain control of his own power supply, the demonstration of any financial saving to be made by the purchase of power would be enough to obtain the load for the power company.

The data required for such demonstrations are not many. The capital which the factory may have sunk in its own plant does not really enter into the question, for the interest and amortisation charges must be borne in any case. The manager has therefore to decide how much he would save in fuel, labour, oil, &c., if power were supplied to him free, and he has to compare this figure with the sum which he would have to pay annually if he purchased power. It is around this last figure that most of the difficulty arises. The trouble is not always that the power company's price is too high. More often than not the reluctance of the manager to enter into a contract for power lies in the fact that the quotation he receives is in such a form that no ordinary man can make out what he will be called on to pay under it, and he cannot therefore determine whether he would be better off by the change. If anyone doubts this statement let him study a few of the tariffs published by our large municipalities or companies, having in mind that he wants to buy, say, round about two million kilowatt-hours per annum and is willing to pay up to 0·75d. per kilowatt-hour for it. For this is the sort of position the average works manager is in. If he is fortunate enough to be in Birmingham or Nottingham and possibly a few other districts, he can determine at once whether he would have to pay more or less than his present cost per unit if he took current from the public supply. But in the great majority of cases he can form no idea. In Glasgow, if we understand the scale of charges correctly, any consumer taking over half a million kilowatt-hours per annum may be called on to pay for as much power as he would have used if he had taken current at his maximum rate of demand for two thousand hours in the year. Under this scheme, therefore, the number of units which he actually uses have little or no relationship with the size of his bill, so that there is no definite price per unit for comparative purposes. Alternatively, he would appear to have the option of agreeing to a charge of several pounds a year for every kilowatt of his maximum demand in addition to a charge for every kilowatt-hour consumed. The latter is indeed a usual form of tariff, but again it renders the bill for power largely independent of the number of units actually used. Leeds further complicates matters by basing the price of its electricity per unit upon the kilovolt-ampères of the power user's maximum load, or alternatively by giving the consumer the option of being supplied at a fixed charge per kilovolt-ampère of his maximum load, with an additional charge per kilowatt-hour on a sliding scale. Here we have load factor, power factor and quantity all taken into account in arriving at the price per unit, thus making a preliminary estimate of the latter practically impossible. Sunderland phrases its tariff in words that have to be read several times in order to gather their purport. This town asks "a rental of £1 per kilowatt per quarter of the consumer's maximum demand, subject to a minimum payment in respect of any quarter's kilowatt demand equal to 50 per cent. of the previous highest quarterly payment in respect of kilowatt demand," and added to this "a unit price of ·55 of a penny per unit for all units up to 25 per cent. load factor, and ·45 of a penny for all units in excess of 25 per cent. load factor." The list of variations and complications could be continued indefinitely. Is it to be wondered at that factory managers often think it better to bear the bills they have than fly to others involving questions of load factor, power factor, duration and magnitude of maximum demand, minimum guaranteed payments, unknown transformation losses, and adjustments, necessary though often of dubious equity, for labour and fuel charges.

It is of hopeful augury that two engineers largely concerned with the provision of electricity to industrial undertakings have recently made public protests against this state of affairs. Mr. W. C. Mountain has expressed the opinion that current should be bought and paid for on the basis of the actual kilowatt-hours consumed, as being the only fair and intelligible one, the price being on a sliding scale or large discounts being given to large consumers. Mr. W. F. Rhodes has also advocated the flat rate system, holding that the "maximum demand" system frequently deters manufacturers from taking power from a public supply. He even goes so far as to say that the inventor of this system, which has been so much lauded by certain persons, did a bad day's work for the cause of electricity supply in this country. Whether this be so or not, the system is certainly not one which appeals to the ordinary manufacturer. In purchasing electricity, as in buying other things, he likes to pay for what he gets, and to know beforehand what he will have to pay for a given quantity. Moreover, as we have pointed out on a previous occasion, however complex the system of charging adopted by an electricity undertaking may be, the price which the consumer has to pay ultimately works out to so much per kilowatt-hour, and much trouble would be saved if the tariff indicated clearly what that sum would be. Contracts would be much more freely entered into and there would be less dissatisfaction afterwards. Attempts have been made to justify the maximum demand system on the grounds that the consumer ought to pay his share of the capital costs of the

undertaking, or that he ought to pay for "service" or for "readiness to serve" or some other intangible factor. But why the suppliers of electricity should be especially entitled to make such conditions is never made clear. There is no business which does not suffer from capital charges and bad load factor, and none which does not have to be ready to perform some kind of service if it is to exist at all. A tube railway, for example, has to earn interest on a huge capital, and it has its peak loads to contend with comparable to those of any power company. Moreover, the "transport" which it sells cannot be stored any more than electricity can. Yet it finds itself able to quote a straight rate per passenger according to distance travelled, and does not expect its customers to contribute independently to its capital charges or to pay for its "readiness to serve."

If, with all the experience they now possess, the majority of electricity undertakings still feel themselves unable to quote a straightforward price per unit of power sold, they might at least agree among themselves upon some common method of charging. It would be absurd to expect them all to charge the same price, but there is no reason whatever why the principle on which their tariffs are based should not be the same in all localities. Such uniformity, besides being logical, would have the further great advantage of improving efficiency by the natural rivalry it would create between the different undertakings. If they feel that load factor must be taken into account, there should be some standard method of dealing with it. Similarly for power factor. Again, clauses concerning the adjustment to be made in case of changes in the price of coal should all be drawn up on uniform lines, which are fair to both parties. They should certainly be identical in all the contracts of a single undertaking, for the variations which sometimes exist at present are not only unjust, but would seem to be perilously near to the differential treatment of consumers, which the Electric Lighting Acts so expressly forbid. The electrical industry has been very successful in various branches of standardisation, and greater uniformity in essentials is bound to follow from the wider outlook of the last few years. The simplification and standardisation of methods of charging still remains as an important work to be taken in hand. When it is accomplished, and the average factory manager can estimate beforehand the price he will have to pay per unit, and can verify the account when presented, the day will be nearer when such industrial load as can more economically be served from the public mains will be transferred from the private plant to the central power station of the district.

Locomotive Efficiency.

ANYONE who listened to Mr. Lawford Fry's paper on a Three-cylinder Compound Locomotive, and the discussion which followed it, at the Institution of Mechanical Engineers on Friday last, December 16th, must have observed the increasing attention which engineers are now paying to the problems of locomotive improvement. It is often said that the steam locomotive is an exceedingly inefficient machine, and it must be confessed that, judged by the standards of stationary steam engines—generally of much greater power—it does consume a great deal of coal per horse-power hour, and that the thermal efficiency of the whole machine is on the low side. But it is not fair to contrast, as the advocates of electrification sometimes do, a moving engine of some 1500 to 2000 maximum horse-power, with a fixed engine of ten times that power, operated under the most favourable conditions, with the benefit of all the heat economising devices which have been invented, and worked for hours at a time on a constant load. The steam locomotive stands by itself. There is no other engine which is expected to meet such remarkable and diverse conditions of service, and it is rather to be praised because it can attain an efficiency of 10 per cent. or so, than blamed because it cannot reach the efficiency of 20 to 25 per cent. reached by a few great power stations. Moreover, the use of "horse-power" in the case of locomotives is rarely satisfactory, for whereas in fixed engines it is easy to arrange to operate them constantly at outputs which give the best results, the locomotive on the road is called upon to develop a great range of power, usually under conditions which make the attainment of high efficiency exceedingly difficult. We might, as a case in point, direct attention to the curious fact illustrated by a diagram given by Mr. Lawford Fry—his Fig. 6—that the steam consumption of No. 60,000 was practically constant for all powers between 1500 and 4500. Mr. Fry's discussion of the causes which contributed to that unusual result shows very clearly the peculiar limitations with which steam locomotives have to contend.

Despite these difficulties and disadvantages, the steam locomotive continues to advance, and it may probably claim to have achieved a percentage improvement on preceding records, in any given recent period, little, if at all, less than that secured by any other steam prime mover. For example, in 1904—we quote again from Mr. Fry—the coal consumption per I.H.P. of a good locomotive was 4·5; in 1923 it had fallen to 3·6; and to-day is as low in some cases as 2·6. That is to say, that in a period of twenty-two years an economy upon the first-named figure of over 40 per cent. has been effected, or, in other words, the coal consumption has been cut nearly in half. That is a rate of progress which the best and largest stationary steam engines have not exceeded or even attained. As a matter of fact, there were stationary steam engines at work thirty years ago with a steam consumption per I.H.P. hour of well under 12 lb., and the best turbines of to-day require 8 lb. to 9 lb. per H.P. hour. Mr. Fry showed that the steam consumption—the water-rate, as it is usually called in America—of heavy freight engines had been reduced by 16·8 per cent. in no more than four years. The record in this country is equally good, and engineers are fortunate in having from Sir Henry Fowler a few comparative figures for engines working the same services. His tables are given on page 706 of this issue, and for our purpose it is necessary to direct attention to but a few items. The "coal per draw-bar horse-power" is a useful figure to consider. In the original "Claughtons," 1913—not very good engines it must be admitted—it was about 5 lb.; it fell to about 4 lb. when the "Claughtons" were modified, and is 3·78 lb. in the standard Midland compounds; then came the "Royal Scot," No. 6100, of this year, and the consumption was brought down to under 3 lb.—it has been as low as 2·66 lb. The "Royal Scot" and her sisters are, as Sir Henry appeared to admit with a tinge of regret, "simple" engines; if he is able, when a chance comes, to design high-pressure compounds for the same service, to effect still further economies, he should succeed in reaching with a "straight" engine on the road the low coal consumption of 2·31 lb., which has been recorded by the Schmidt super-high-pressure locomotive on a test plant. With other improvements which are in prospect—the employment of poppet valves, for example—the steam locomotive should advance still further in efficiency, and if it can never hope to attain, yet may approach the low coal and water consumptions which stand to the credit of engines working under more favourable conditions.

When studying the tables and diagrams given in Mr. Lawford Fry's paper and similar material from other engines which have reached us from America we have always been impressed with the real value which the locomotive engineers of the United States derive from the possession of a first-rate testing plant, and we never cease to regret that there is no comparable plant in this country. In his presidential address to the Institution of Locomotive Engineers Mr. Gresley alluded to this matter, and we may express a hope that some efforts will be made to secure an adequate plant of the kind for Great Britain. There can, we hold, be no question of its value. It would enable locomotive designers and engineers to investigate with all the refinements of a test-house problems which have now to be tackled under the very difficult and frequently baffling conditions of road tests. It is greatly to the credit of our locomotive men that they have gone so far without the means for conducting scientific inquiries which exist in America and Germany. But every day that goes by makes mechanical engineering a more precise science and we can hardly hope to keep pace with our compeers in other lands if we have not equipment equal to theirs. The prime mover locomotive is now passing through a very critical stage. Side by side with the improvement of the steam engine we see the advances of oil engine-driven locomotives, and we do not know what else the future may have in store. It is certain that, without the means of testing new inventions and designs by scientific methods, development will be hindered and our progress both in the manufacture of engines for our home railways and for export will be delayed.

ARRANGEMENTS are being made for extensive development of the large deposit of molybdenite at Lake Malartic, south of Amos, Quebec.

Obituary.

THOMAS FENDER.

WE have to announce, with regret, the death of Mr. Thomas Fender, a Special Director at the Barrow Works of Vickers Ltd., which took place at Purley, Surrey, on December 14th.

Mr. Fender, who was 63 years of age, served an apprenticeship at the Elswick works of Sir W. G. Armstrong and Co., Ltd., where he became Foreman of No. 11 shop at the age of 26 years, and was appointed Chief Ratefixer at the age of 29.

It was at the Barrow Works of Vickers Ltd., however, that he proved his real worth as an executive official. His connection with that firm began in 1901, when he was appointed Chief Ratefixer, and two years later his name was especially identified with a Premium Bonus System, which was successfully put into operation at the Barrow Works under his special supervision. In 1910 he was appointed Superintendent of Workshops, and when the size of the undertaking at Barrow is borne in mind, it will be realised how great a responsibility that position carried with it.

His particular gifts were such, however, that his company employed them with good effect in other directions than at Barrow. He was, for instance, deputed to act in a joint supervisory capacity in connection with the Erith Works of the firm, and was also sent to Italy for work concerned with the Vickers Terni establishment and to Russia for the organisation of a works at Nicolaieff.

During the world war, not only were his responsibilities at Barrow considerably increased as the result of the great influx of work on armament and shells—for which new plant had to be purchased and new shops built—but on him devolved the work of establishing and equipping, at short notice, a national projectile factory at Lancaster, and a shell-filling factory at White Lund. For his work in this connection he was made O.B.E., and the officials and workmen of the company presented him with a bound illuminated address, which all had signed, to mark the event. It was shortly afterwards—in December, 1919, in fact—that he was made a Special Director by Vickers Ltd.

Owing to ill-health, Mr. Fender had to retire from business in 1925, much to the regret of those with whom he had been associated in work.

Literature.

Jane's Fighting Ships, 1927. Edited by OSCAR PARKES and F. E. MCMURTRIE. London: Sampson Low. Price 42s. net.

THE new edition of "Jane" is of quite exceptional interest. It contains photographs, diagrams, and very complete data of the large number of British and other warships of post-war construction which have passed into service during the current year. Thanks to assistance rendered by the various Admiralties, and by enthusiastic correspondents all over the world, the editors have been able to compile a full and authentic record of all recent developments in the sphere of naval shipbuilding. Certain sections have been almost entirely re-illustrated, and there are up-to-date views of every fighting ship of any importance, irrespective of the flag she flies. In the British Navy section the eye is at once attracted by a fine series of illustrations of the Nelson and Rodney, which the camera has caught from almost every angle. These mastodons appear to greatest advantage in the full broadside views. Although the profile may outrage all the rules of symmetry as applied to marine architecture, it has a certain austere beauty of its own. It certainly conveys an impression of tremendous fighting power, by reason of the grouping of all the nine big guns in the fore part of the ship. The great length of the hull produces an optical illusion of low freeboard, but the ships are, in fact, high-sided, and have already proved themselves excellent seaboats. It will be interesting to see whether this bold design is repeated in later battleships. Further striking views are those of the aircraft carriers, including one that displays the flight deck of H.M.S. Eagle, and a spirited drawing, by Dr. Parkes, of the Courageous as she will appear after reconstruction. Other noteworthy illustrations in this category of vessel are those of the French Béarn, the U.S. Saratoga and the Japanese Hosho and Akagi—the last-named evidently a close copy of H.M.S. Furious. Full justice is done pictorially to our latest cruisers, beyond doubt the handsomest cruising ships built for the British Navy since the days of Sir William White. They have the graceful contour of an ocean liner, nor is the effect marred by the 8in. gun turrets at bow and stern. All the newest destroyers and submarines are illustrated, among them H.M.S. Oberon and the Australian boats, Oxley and Otway.

In the Argentine section there is a special drawing of the two cruisers which were ordered recently from Italian yards. Displacing only 6800 tons, they are engined for 32 knots and carry an armament of six 7·5in. guns in twin turrets, besides twelve 4in. on H.A. mountings, and six torpedo tubes. As the water-

line and the gun turrets are protected by armour, it will be agreed that the designers have made the most of their disposable weight. Plans are furnished of the big torpedo craft which are now building in England for the navies of the Argentine and Brazil. In the French section are photographs—some showing details of armament and tophamper—of the latest cruisers, destroyers, and submarines. The new flotilla leaders are ships of 2780 tons and 36 knots, mounting six 5·5in. guns. They are virtually light cruisers in all but name. The pages devoted to French submarine construction are deserving of study. Germany's small but workmanlike fleet is well represented. There are views of the reconstructed battleships, the powerful cruisers of the "Königsberg" class—6000 tons, 32 knots, nine 6in. guns—and the new destroyers. Certain photographs reproduced in the Italian section show that navy to be paying considerable attention to aviation. The 10,000-ton cruisers Trento and Trieste are depicted, but few details can be given of the four light cruisers which are about to be laid down for the Italian fleet. Their displacement is to be 5300 tons, they are to be armed with "6in. guns of a new and powerful model," and the designed speed is "believed to be 37 knots." Japan has been working for some years on a large programme of reconstruction, the results of which are here illustrated. All her capital ships and several of the cruisers have had their appearance altered by modifications of funnels, masts, and upper works. The United States Navy, as exhibited in these pages, appears to be a great deal more formidable than might be inferred from the alarmist statements now being circulated in America. In every type of vessel save the cruiser it is as strong as, if not stronger than, the British Navy. It has already a very marked preponderance in destroyers and submarines. It will soon have in service the largest aircraft carriers, the most heavily-armed cruisers, and the largest submarines in the world. Moreover, the fighting value of its older battleships has been substantially increased by extensive modernisation.

It is clear that the editors have taken unlimited pains in the preparation of this volume, which does great credit to their technical knowledge, judgment, and industry. Throughout the thirty years of its career, "Jane's Fighting Ships" has never had a serious rival, and to-day it stands unchallenged as the only illustrated encyclopedia of the world's navies.

Materials and Design in Turbo-Generator Plant. By O. LASCHE. English Edition by A. L. MELLANBY, D.Sc., and W. ROYLANDS COOPER. London and Edinburgh: Oliver and Boyd. 1927. Price 24s. net.

IN writing the preface to the second German edition of this book, the late Dr. Lasche made it clear that he regarded it as a kind of constructive protest against the way in which students are too often taught to regard engineering at college. As a practical engineer of great experience, he wished to reform engineering education by bringing into prominence the real questions which confront designers, questions which are too much ignored by teachers because they cannot be made amenable to mathematical treatment. There is, however, not a word of educational polemics in the book itself. Dr. Lasche chose to make his point by discussing the knowledge which the engineer should have concerning the nature and behaviour of metals in order that he may be able to produce safe and reliable turbine machinery. It is significant that questions concerning thermodynamic efficiency are entirely ignored. This may have been because the author realised that there was already a surfeit of literature on the subject, but the more probable reason is that he wished to emphasise the fact that the attainment of a high thermodynamic efficiency is a secondary matter in comparison with the ability to construct a machine which will run for long periods without risk of disaster or chronic trouble. Fortunately, these two desirable features are not mutually exclusive.

So far as it is possible to summarise the plan of the book in a few words, it is an account of tests of material and of component parts of turbo-generating machinery and of researches in connection with them, carried out by the Allgemeine Electricitäts Gesellshaft, all being accompanied by illuminating comments. When the third German edition was prepared by Dr. Walter Kieser, after the death of Dr. Lasche, the same practical note was adhered to, further chapters being added by other writers in accordance with the general scheme of the work. It is the translation of this edition into English by Dr. A. L. Mellanby and Mr. Roylands Cooper which constitutes the book before us.

Although the volume is centred entirely upon the turbo-generator practice of the great company with which its author was connected, so much of the matter necessarily applies to turbine machinery generally, and even to machinery of other kinds, that there is hardly a mechanical engineer who would not find it interesting throughout. The appeal of many chapters to the metallurgist is equally great. It is not a text-book either of design or of metallurgy, nor is it intended to be. It is rather a record of things the author found important in connection with the strength or durability of metals under working conditions; a description of experiments and researches bearing on these matters; an account of the applications of the knowledge so gained to the betterment of design; and, further, it contains a large number of most instructive illustrations of the failure of metallic parts to withstand the erosive, corrosive, or other destructive conditions to which they were subject in working. The illustrations, and particularly the photographic reproductions, are indeed notable for their excellence. They include a large number of photo-micrographs of metals, about thirty of those dealing with the corrosion of various brasses being reproduced in colours. As the whole of the book is printed on "art" paper, with a highly glazed surface, these photo-micrographs show an amount of detail which will even bear examination through a lens, and the colour plates especially constitute a striking feature of the volume.

The first three of the ten chapters which together constitute the book are mainly concerned with the behaviour of metals under tensile, notch and fatigue tests. The practical proof that the stretching of a bar beyond its elastic limit seems actually to improve the material is one which ought to be convincing to students. It is also interesting in view of the fact that during the war one manufacturer of H.E. shell subjected every finished shell to an internal hydraulic pressure calculated to stress the material to a point which would have been just below the elastic limit had the steel been of the quality desired. If the steel was softer than the specification the elastic limit was passed, and the shell took a permanent set. After being skimmed up in the lathe to restore the correct diameter, it would always pass a repetition of the hydraulic test, as the elastic limit had been artificially raised, and tensile test pieces cut from shells so treated showed the material to be up to specification in every respect. The fact that material can be improved by stretching beyond the elastic limit has a further practical significance. From test bars cut from an overstressed piece, after a breakdown, the maximum stress at that particular point to which the metal was subjected, when running, may be estimated. It follows also, as Dr. Lasche points out, that it is misleading to use samples cut from such a piece for the purpose of estimating the properties of the metal in its original state. He concludes, in a general summary, that "the results obtained from the different methods of testing material all seem to contradict each other, at least in regard to . . . the highest stresses which may be applied with safety." From this sad but true statement he draws the only inference possible, namely, that the method of testing chosen should be adapted as far as practicable to reproduce the stresses to which the finished article will be subjected under working conditions.

The next chapter deals with the forging and heat treatment of turbine wheels, the stresses caused by excessive speed and unequal heating, and the mounting of wheels on their shaft. Then the author considers blading, forms of blade roots, materials suitable and unsuitable for blading, with a number of wonderfully good photographs showing the effects of bad material and the destructive consequences of impure steam, high temperature, &c. The method adopted by the A.E.G. for testing blades under vibration is fully described. The next chapter is a short one on the growth of cast iron, with analyses of iron recommended to withstand temperature changes. Generator rotors are next discussed—that is, in so far as the A.E.G. practice of construction and test are concerned. The two last chapters in the book deal respectively with corrosion of condenser tubes, and with experimental researches on turbine bearings. They are both of the highest interest, as representing deductions from a wide knowledge freely given for the benefit of other engineers. The former is the more striking by reason of the wonderful coloured photographs, to which allusion has already been made, but the latter comprises such a detailed account of experiments on bearings that it will appeal to every designer. The whole of the book, indeed, makes this appeal. It is like no ordinary treatise or text-book. Where practice is discussed it is frankly that of the A.E.G., with no suggestion of comparison with that of other makers. The experienced reader, indeed, may sometimes think that Dr. Lasche did not know all that there is to be known on certain points of design, and he himself would probably have been the first to admit it. But he has produced one of the most useful and interesting books ever written for engineers concerned with turbine machinery, and the translation into English is as good as it could be.

The Working of Coal and Other Stratified Minerals. By H. F. BULMAN. London: Ernest Benn, Ltd. 1927. 42s. net.

EMERITUS PROFESSOR HENRY LOUIS, M.A., D.Sc., the editor of this series of mining books, in his introduction emphasises that "the actual extraction of the mineral must always remain the most important task of the mining engineer."

The author has made a selection of many important methods of working as practised in the mining of coal under wide and diverse conditions in important parts of the British Empire, the Continent and America, but additional descriptions and illustrations showing the modern application of coal cutters and conveyors to longwall working in this country would have added to the value of the book. More attention might have been given to proportion and details in some of the illustrations. Particulars of methods of working adopted in America form an excellent feature of the book; too much attention cannot be paid to the application of machinery in mining. The interesting chapter on hydraulic stowage would have been greatly enhanced by the insertion of more detailed illustrations showing latest practices. Figures relating to costs appear to render the general application of this method of packing prohibitive in Great Britain. In Chapter XV. the author pays special attention to "holing" with a view to ensuring the maximum amount of coal free from dirt being sent out of the mine. With regard to safety, comparative figures of the amount of explosives used in Great Britain and America are useful, and the instructive matter on various methods which have been tried with a view to reducing the amount of explosives used in mining is welcome. In addition to the mining of coal the author describes the mining of other stratified deposits, namely, ironstone, shale, rock salt, potassium salt, china clay, slate, limestone and gold. In a work of this kind a good index and ample references are essential, and in this respect the book reviewed provides all that is required.

SHORT NOTICES.

The 20th Century Business Book. A practical guide to efficiency, comprising every branch of business. Edited by Walter Grierson, assisted by expert contributors. In four volumes. London: The Home Library Book Company. 1927. Price £4 net.—These well-produced volumes form a sort of encyclopædia of business. We take it that they are meant rather for the general reader than for the specialist and for the home rather than the office. So many people are interested in business nowadays and so many know nothing about its methods that a book of the kind may prove acceptable and do good. The volumes are plentifully illustrated, more often than not with the object of showing the magnitude of business rather than because the pictures illuminate matters under discussion. We can best give, briefly, some idea of the contents by quoting the titles of a few sections selected at random:—Limited Liability Companies, Modern Accountancy, Bills of Exchange, Salesmanship, Commercial Management, the Money Market, Factory Organisation, Commercial Law, Debts and their Recovery, Banks and the Law, Business Correspondence, Insurance, Income Tax. It will be seen that the scope is a wide one. Most of the chapters are fairly long, and the treatment aims rather at being attractive than at great profundity, but the volumes will appeal to the average man who wants an outline and not a complete picture.

BOOKS RECEIVED.

Bulletin No. 24 on Pollution of Streams in Illinois. Illinois: The State Water Survey Division, Urbana, U.S.A.

Annali dei Lavori Pubblici (già Giornale del Genio Civile), Ministero dei Lavori Pubblici, Consiglio Superiore, 1927. No. 9, Settembre. Rome: Provveditorato Generale dello Stato Libreria.

SIXTY YEARS AGO.

IRELAND and the Fenians were the cause of great troubles sixty years ago, but except for a passing allusion our columns gave no indication of the fact until we reach our issue of December 20th, 1867. In that number a woodcut, apparently based on a photograph, headed "The Clerkenwell Explosion," attracts our attention. The engraving shows a high brickwork wall widely breached, with a mass of *débris* in the foreground, and through the gap some mean tenement buildings unroofed and shattered. It was the work of the Fenians. The wall was the boundary of the Clerkenwell House of Detention, within which some of their brethren were held prisoners. The conspirators placed a barrel of gunpowder against the outside of the wall in Corporation-lane and fired it. How many of the prisoners succeeded in escaping in the confusion which followed, or what casualties were inflicted on the occupants of the houses on the other side of Corporation-lane, we did not record. It would appear that no prisoners were in the yard at the time of the explosion; otherwise it would clearly, as we remarked, have been a case of "save me from my friends." We were not concerned with the political aspects of the outrage, but took occasion to use it as a practical lesson of the general effects caused by explosions. It seems that many rumours were afloat regarding the nature of the explosive that had been employed. An "Officer of the Household Troops" had stated that it was probably nitro-glycerine, a substance then but recently introduced. Others imagined that it was petroleum in some strange form. We disposed of both ideas and asserted that all the damage that had been done was well within the compass of 150 lb. of coarse blasting powder. The effects caused by the explosion were, as always, of a curious and apparently contradictory kind. The destruction wrought on the wall of the prison was largely aided by the fact that on the prison side the ground level was some 5ft. below the level of the street outside. On the houses the effect differed according to the soundness of the brickwork and the orientation relatively to the point of explosion. Curiously enough, while the fact that in some cases windows and walls were blown *outwards* was recorded, no attempt was made to provide an explanation. That phenomenon was very marked in the case of another London explosion within our own times, the Silvertown disaster of 1917. It is now generally agreed that in an explosion within an area closely covered with houses, the worst destruction outside the immediate area affected is caused not by the sudden rise of pressure accompanying the advance of the wave front, but the sudden fall which occurs after the crest has passed.

13,330 kVA. Vertical Water-wheel Alternator.

THREE vertical water-wheel alternators of large size, each machine having a normal rating of 13,330 kVA, have recently been built by the Metropolitan-Vickers Electrical Company, Trafford Park, Manchester. Together with water turbines, which have been constructed by Escher Wyss and Co., of Zurich, they form the initial equipment of a large new power station on the Maipo River in the High Andes in Chile. The sets have been supplied to the order and specification of the Whitehall Securities Corporation, Ltd., of London, on behalf of the Compania Hidro-Electrica Volcan of Santiago, and the plant will supplement the existing supply of power in bulk by means of an overhead system at 110,000 volts, to undertakings in the Santiago and Valparaiso districts for lighting and industrial power services and also for tramways and main line railways. The site of the new station is about 40 miles south-east of Santiago, at a height of 4250ft. above sea level.

The water turbines are of the Pelton wheel type, each unit having a capacity of 18,600 horse-power, with a water supply of 1870 gallons per second at the existing head of 670ft. The decision to adopt turbines of the Pelton type, in spite of their higher initial cost, was largely influenced by the fact that the water contains a large amount of gritty sand, for the impulse type of turbine has a greater ability to withstand the action of sand, and gives greater facility of replacement of worn-out parts, than do turbines of the Francis type. The vertical type was adopted on account of the comparatively small space required, and the possibility of employing the relatively high speed of 250 r.p.m. by providing each unit with four inlets.

The arrangement of the turbines can be seen in the sectional elevation of a complete generating set shown in Fig. 1 and in Figs. 3 and 4. Whereas in turbines hitherto built by Escher Wyss and Co. the pipe distributing the water to the jets is arranged in a plane situated below or above the wheel, in the Maipo turbines it is situated on the same level as the wheel, and is fitted on its inner periphery with four inlets, each equipped with a needle which passes through it—see Fig. 3. This pipe or "spiral" is built into the base of the set. The advantage claimed for this arrangement lies in the fact that it gives easy access to, and easy control of, all portions of the machine, and, moreover, it enabled the designers to reduce the height of the sets and to build them with two guide bearings only.

The generator stator is connected to the turbine spiral by means of a cast iron solid yoke—see Fig. 3—provided with large apertures giving access to the bottom guide bearing, governor driving gear and the gear operating the deflectors. The bottom guide bearing is situated close to the wheel, and is fitted with an oil pump built in the oil sump, and so arranged that it can easily be lifted and overhauled. The pump supplies the oil to both guide bearings.

The turbine is separated from the bottom guide bearing by protecting shields of cast iron in the shape of a dome which deflects the water thrown up by the wheel. These protecting shields being directly exposed to the action of the water, which, as mentioned above, is very gritty, great care had to be taken to design them in such a way that they would exactly fit each other. They had, at the same time, to be easy to handle and to replace. The four needles are actuated by an oil pressure servo-motor arranged on the same level as the needles. Another servo-motor, which operates the four deflectors, is situated on a raised platform, which also carries the operating gear for the governor and for the main valve, the oil pump and the air vessel. This arrangement had to be chosen because the connecting gear for the oil pump and pendulum were situated above the bottom guide bearing. It has, however, the advantage of concentrating all the controlling apparatus on one place, whence the set can be easily surveyed.

The wheel is fastened on to a tapered shaft extension by means of a key and nut. For overhauling, it can be lowered down the wheel pit and hauled into the power-house through a special pit provided in the floor. It has twenty buckets of cast steel, which are attached to the disc by conical bolts. For inspection purposes, and in order to facilitate the replacement of the wearing parts of the thrust bearing, the whole rotating part of the set can be lifted by means of a jack arranged in the wheel pit underneath the shaft end. The parts of the deflectors, nozzles and needles, which are exposed to the action of the water and subject to erosion are made of high-quality steel and are easily replaced. These parts are of such simple design that they can easily be made in the power company's own repair shop.

THE ELECTRICAL GENERATORS.

The generators are rated at 13,330 kVA at 12,000 volts, three-phase, 50 periods, and a power factor of 0·9 lagging.

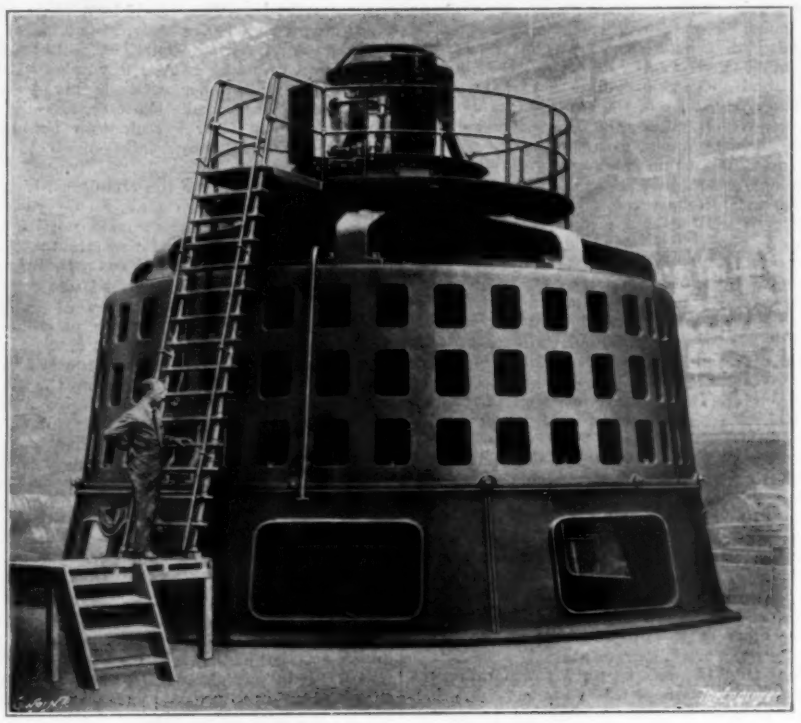


FIG. 2—13,330 K.V.A. THREE-PHASE ALTERNATOR

The guarantees of temperature rise are based on the normal rating, but the machines are capable of operating satisfactorily over long periods at 10,800 volts and normal full-load current or at 13,200 volts and normal full-load kVA. Rise of temperature, as measured by the resistance of the stator and rotor windings, is guaranteed at not more than 50 deg. Cent. at normal output, with an inlet air temperature of 40 deg. Cent. and at an altitude of 4250ft. The equivalent temperature rise, if tested at sea level, would be 48·5 deg. Cent. Six thermo-couples are embedded in the estimated highest temperature positions in the stator slots of each alternator, and the equipment of each unit includes a temperature indicator fitted on the machine itself.

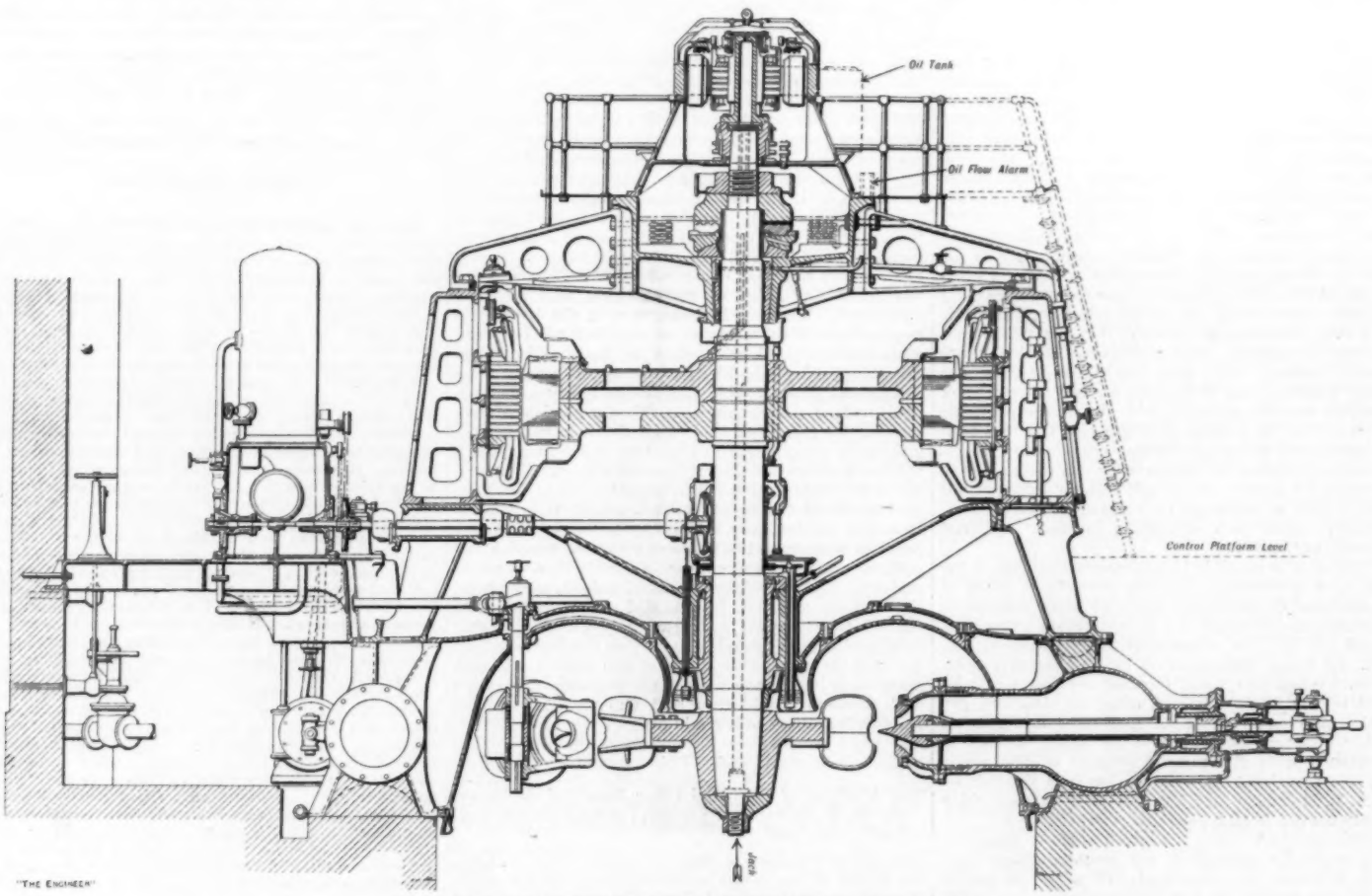


FIG. 1—18,600 H.P. VERTICAL-SPINDLE PELTON WHEEL ALTERNATOR

The guaranteed efficiency and regulation of the machines when operating at 250 r.p.m. are shown in the following table, together with the test results obtained :—

Power factor.	Load.	Efficiency, per cent.		Regulation, per cent.	
		Guaranteed.	Obtained.	Guaranteed.	Obtained.
1·0	Full	95·65	96·49	18·5	18
1·0	¾	95·25	95·96	12·5	12·4
1·0	½	94·0	94·66	6·5	6·8
1·0	¼	89·8	90·53	2	2
0·9	Full	95·25	96·13	28	29·8
0·9	¾	94·9	95·65	22	23
0·9	½	93·8	94·44	15	15·8
0·9	¼	89·6	90·39	7·5	7·8

Excitation current is provided by a 220-volt exciter of adequate capacity for maintaining normal kVA output at 13,200 volts, and designed to give a desirable form of magnetisation curve for use with an automatic voltage regulator.

The stator of each machine is built up in four sections to facilitate transport, each section being shipped separately with its own part of the core assembled and with the winding in position, except for the coils bridging the joints. One stator section thus assembled, but with the greater part of the air baffles removed, to show the windings, is seen in Fig. 5. The four castings which constitute the yoke are of hollow box form with heavy ribs, which are machined with dovetailed grooves to take the punchings. An upward extension of the yoke screens the windings and forms a support for the upper bracket. The yoke, assembled, stands 6ft. 8in. in height, is 21ft. 3in. in diameter, and weighs 25 tons.

The core consists of 21 tons of segmented stampings of high-grade sheet steel, each sheet insulated on one side by a layer of paper. All laminations throughout the machines have their edges ground to remove burrs after punching. The core segments are secured to the yoke by dovetailed projections on the stampings engaging with the corresponding grooves in the axial ribs of the yoke. The whole core is assembled under pressure and clamped between heavy, segmental end plates by bolts, which pass entirely outside the stampings. This arrangement eliminates all possibility of damage to the core, owing to eddy currents resulting from failure of the bolt insulation, which would otherwise be necessary.

The stator winding is of the two-layer diamond-coil type, all coils being identical and completely formed and insulated before being placed in the slots. Each conductor is built up of copper strips of rectangular section, which are separately insulated throughout with mica silk tape to reduce circulating currents. Each complete conductor is further insulated from adjacent turns in the same coil side by another layer of mica silk tape. The slot portion of the coil is finally insulated from the core by a heavy micafolium wrapping applied by means of a special machine which tightens the wrap by the rolling pressure of hot irons. The wrap thus applied is subjected at suitable stages to a pressure of more than 1 ton per square inch at a high temperature and is allowed to cool under this pressure. This process gives an insulation in which internal air spaces are entirely eliminated, and which has a mica content of more than 70 per cent. by weight. The coil ends are insulated with Empire cloth tape, each successive layer of which is treated with insulating enamel. The insulation of the coil ends and that of the slot portion are securely sealed together in a long double-scarfed joint. In the assembled winding the coil ends are firmly clamped to withstand short-circuit forces. Every coil is corded to an insulated steel ring, which is carried on angle brackets bolted to the core end plates and packing blocks are inserted between adjacent coils to prevent peripheral movement.

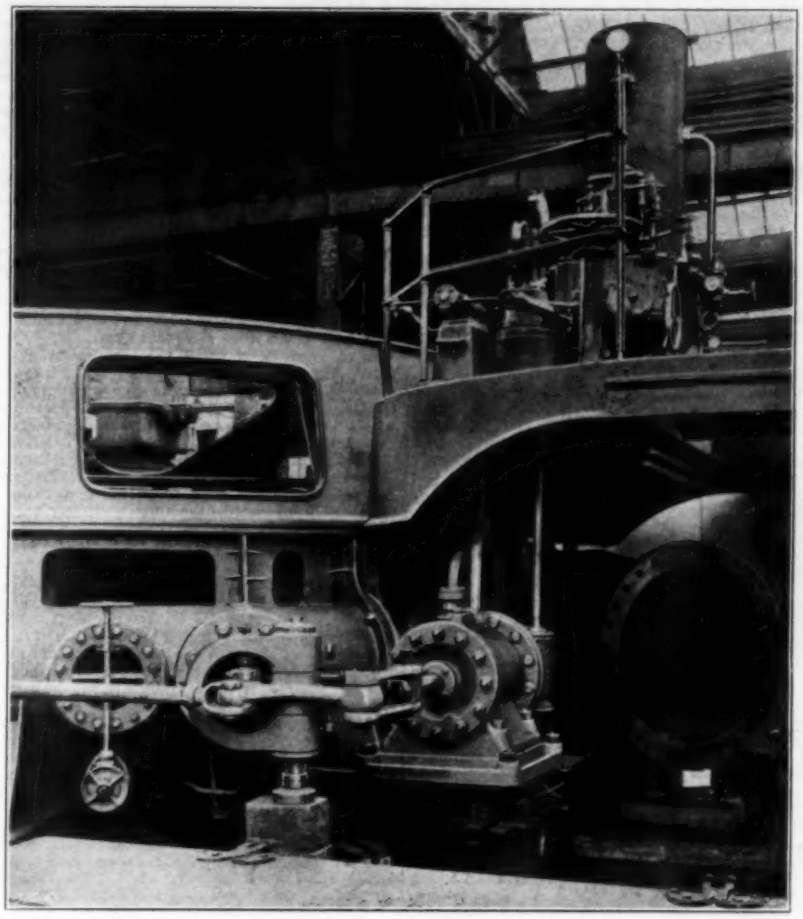


FIG. 4—CONTROL MECHANISM, MAIN INLET AND SERVO MOTOR

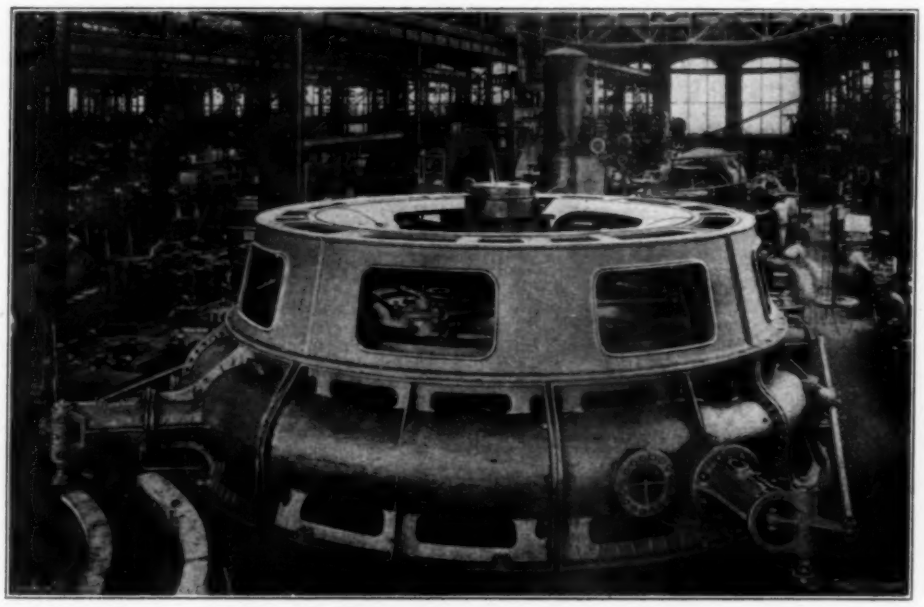


FIG. 3—VIEW OF TURBINE SHOWING DISTRIBUTING PIPE

The main terminal cables are brought out through the yoke and the base ring to sealing boxes placed under the control platform. The neutral leads are taken through the transformers of the Merz Price protective gear, which are mounted on the upper bracket of the alternator.

The rotor spider is shown in Fig. 6. It consists of two cast steel wheels, each 11ft. 5½in. in diameter, 15in. in thickness, and weighing 12½ tons. The wheels are pressed on to the shaft with a sufficient interference to ensure their remaining tight at the runaway speed. They were cast with a solid web to avoid local shrinkage stresses, suitable openings for ventilation being afterwards machined in the web of each wheel. To ensure the satisfactory physical properties of each casting, test pieces taken radially and axially from various parts were subjected to tests in the research department at the makers' works, and, in addition, the surfaces of the castings were machined all over and subjected to thorough examination.

The twenty-four poles are built up of heavy gauge stampings clamped under hydraulic pressure between cast steel end plates of semi-circular section by a number of heavy bolts. The stampings and end plates have overhanging flanges which support the coils throughout their periphery. Each pole, weighing just over 15 cwt. with its coil, is attached to the spider by a dovetailed projection formed on the stampings and end plates, this projection being finished accurately to a carefully calculated press fit in the corresponding slot machined in the periphery of the magnet wheels. The design of dovetailed joints for this purpose has been the subject of extensive and thorough investigation by the Metropolitan-Vickers research department, as a result of which a standard dovetail profile has been devised securing maximum uniform strength at all points of the dovetail in both pole and wheel. The poles are forced into place by means of a 50-ton hydraulic press operated by a small hand pump, the maximum pressure employed being carefully controlled so as to keep the stresses in both dovetails and spiders within known and safe limits. Complete pressing tackle is supplied with the sets for use on the site. The poles are made interchangeable and are capable of repeated removal and replacement without loss of fit.

The field coils are of copper strip wound on edge with treated asbestos paper between the turns. After winding the coils were pressed, while electrically heated, with a load exceeding the centrifugal force at the runaway speed, so as to ensure that no further compression or shrinkage can occur in service. Each complete coil was then mounted, still under pressure, on a sheet steel spool with brass end flanges from which the coil is insulated by flexible micanite. The spool serves to hold the coil compressed and securely in position, as the brass flanges are subsequently machined to make the spool an exact fit between the pole tips and the rotor body.

The rotor shaft is an annealed carbon steel forging 21ft. long, 21in. maximum diameter, and weighing about 8½ tons finished. Besides having its physical properties checked by test pieces, as in the case of the cast steel

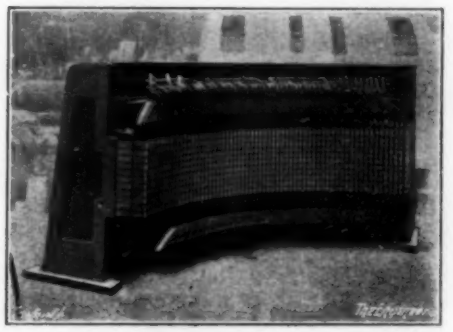


FIG. 5—STATOR SECTION WITH AIR BAFFLES REMOVED

wheels, it is bored throughout its length for purposes of microscopic inspection of the interior, the bore being subsequently used to carry the leads from the rotor to the slip-rings through the thrust bearing and the upper guide bearing. The whole surface of the shaft is machined and all journals and seatings ground to limit gauges. The lower end of the shaft has a conical seating and keyway for coupling to the water-wheel. The upper end is tapered for the sleeve mounting of the exciter. One of the rotors completely assembled is shown in Fig. 7.

The machines are guaranteed for an overspeed of 100 per cent., and a test to that speed was carried out on each complete rotor in the overspeed test-house of the Metropolitan-Vickers Electrical Company at Trafford Park. Some idea of the forces involved in the testing and running of such large machines is given by the fact that in this case each pole of the rotor exercises at the test speed of 500 r.p.m. a centrifugal force of 410 tons.

The exciter armature and the slip rings are mounted

on a sleeve fitting on the tapered end of the main shaft and secured by a nut. The arrangement is such that they can be removed without dismantling any other part of the rotor. The exciter is shunt wound, with interpoles, and is provided with saturation plates, giving stability at the low voltages required when the alternator is used for line charging. The entire excitation control is effected by a rheostat connected in the exciter field circuit of each alternator. The rheostats are arranged for remote mechanical operation by means of sprockets and chains from hand wheels on the switchboard.

THE BEARING BRACKET AND BEARINGS.

The entire weight of the rotor, together with the exciter and the runner of the water turbine, totalling 75 tons in

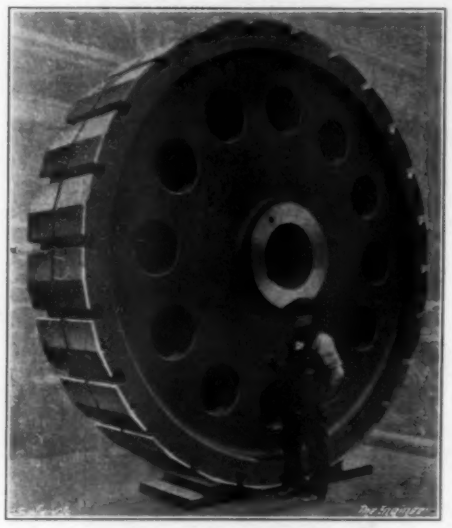


FIG. 6—ROTOR SPIDER

all, is carried on the upper bearing bracket by means of the thrust bearing, which is mounted in it. The upper bearing bracket consists of a casting 8ft. in diameter, 4ft. in depth, and weighing 7 tons, which forms the oil well and the housing for the thrust bearing and the upper guide bearing. The eight arms are of cast steel, 5ft. 4in. in length and weighing just over 1 ton each. They are bolted to the central casting and register under a lip at the top. The outer ends of the arms are provided with pads which rest upon and are bolted to the yoke. At these points, and also in all the pipe and ladder connections, insulation is inserted to prevent the passage of induced circulating currents, which might damage the bearings.

The bearings of each set consist of a thrust bearing and two guide bearings. The thrust bearing is of the Michell type, designed and manufactured by the Metropolitan-

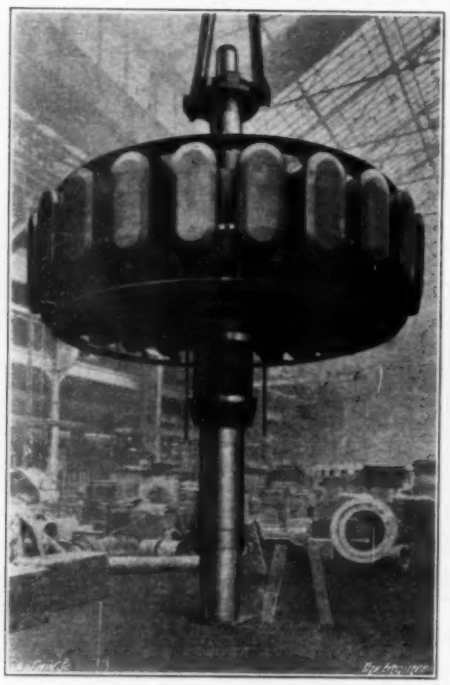


FIG. 7—COMPLETE ALTERNATOR ROTOR

Vickers Electrical Company. It is rated at 75 tons, at which load the bearing pressure on the eight pads which carry the weight is 250 lb. per square inch. The thrust collar is of cast iron, steel faced, and weighs nearly 2½ tons. It is secured to the rotor shaft by a massive nut, which itself weighs more than half a ton. The nut has two large lugs by which the whole rotor may be lifted, as shown in Fig. 7. The pads are of cast iron, faced with high quality white metal, and are carried on the upper of two cast iron levelling washers, the bearing surface between which is spherical. In the assembled arrangement, radial movement of the pads is prevented by stop plates secured by screws to the upper levelling washer. The pads, which weigh about 120 lb. each, can be readily removed when the stop plates are withdrawn and the rotor shaft jacked up. The whole bearing runs in the oil well, which constitutes the central part of the upper bearing bracket. Leakage down the shaft is positively prevented by means of a tube surrounding the shaft, and concentric with it, rising above the oil level of the well and sealed to the lower levelling washer.

The capacity of the oil well is such that it is unnecessary to circulate the oil externally for cooling. The natural circulation is so arranged that cool oil is drawn from the bottom of the oil well and the hot oil leaving the bearing surfaces is thrown into a nest of copper pipes seen in section in Fig. 1, through which flows cooling water. The oil having been cooled, falls to the bottom of the well and is again circulated. A drain is fitted by means of which the oil in the well may be drawn off when necessary for reconditioning.

The guide bearings are both white metal lined, the upper bearing being mounted in the top bracket immediately beneath the thrust bearing, with a taper seating to facilitate removal, and the lower, supplied by Escher Wyss and Co., being mounted immediately above the runner wheel. Both bearings are arranged for lubrication by a continuous flow of oil and are suitably grooved to feed oil throughout their full depth. The oil supply is delivered by a pump which runs submerged in the oil sump of the lower guide bearing, and which is directly driven by gears from the main shaft. The circulation is effected through a small tank mounted alongside the exciter, arrangement being made so that when the machine is being started this tank can give a supply of oil to the guide bearings before the pump becomes operative. Sight-feed lubricators are provided, and an alarm system is installed to give warning by means of a Klaxon horn in the event of the oil supply to either bearings failing. Thermometers are placed in the thrust bearing and in the two guide bearings, indicating the temperatures of each upon dials mounted, together with the thermo-couple indicators, upon a board on the yoke.

VENTILATION.

A simple system of radial ventilation is adopted. The spaces between the arms of the upper bracket are closed by sheet steel covers and the cooling air is taken in at the bottom through the base ring by the action of fans mounted at the top and bottom sides of the rotor. The air supply to the upper half of the machines passes through the large circular holes cut in the magnet wheels. In both the upper and lower parts of the machine part of the air is driven by the rotor fans over the ends of the field coils and through the stator coil ends, being discharged directly through the back of the yoke. The remainder of the air passes between the poles, cooling the field coils, and is discharged through radial ducts provided in the stator core. The cooling of the centre of the machine is assisted by air, which is drawn by the fanning action of the poles and passes through a space formed by distance pieces between the rims of the magnet wheels. The total circulation of cooling air, as shown by test, is approximately 90,000 cubic feet per minute.

TESTS.

The completed machines were tested to establish both the open circuit and the closed circuit characteristics. The friction and windage and open circuit and short circuit losses were measured by means of a direct-current driving motor mounted upon the top of the machine in place of the exciter. The efficiencies deduced from the results are shown in the table. The heating test was carried out by operating the machine on open circuit and short circuit alternately for half-hour periods until steady temperatures were reached. The open-circuit voltage and the short-circuit current were selected, so that the average total losses in the machine under the two conditions were equal to the actual losses on full load, while the average heating of each part is also made as nearly as possible equal to full-load conditions. The results of this heating test were as follows :—

Temperature Rise, at Sea Level.

How measured	By resistance* Deg. C.	By thermometer. Deg. C.
Stator—		
Winding	46	—
Core	—	25
Coil ends	—	32
Rotor—		
Winding	24	22
Core	—	10

* Guarantee, 50 deg. Cent. at 4250ft., equivalent to 48·5 deg. Cent. at sea level.

Immediately following the heating tests the insulation resistance was measured and pressure tests applied to the stator and rotor windings. The stator winding was tested between phases and to earth at 27,000 volts for one minute, and the rotor winding and exciter circuit at 2000 volts for one minute, the tests being made with alternating current at 50 cycles. Oscillograms were taken of the line voltage and phase voltage of the machines on open circuit and showed entire absence of both low-frequency harmonics and slot ripples.

WEIGHTS.

The following dimensions and weights of the complete machines are given in addition to figures already given for some of the component parts :—Each alternator with its exciter is 15ft. 7in. in height, and each set stands 25ft. 5in. in height from floor level, with an overall diameter of 21ft. 3in. The total weight of each alternator is approximately 128 tons, of which 31 tons is the weight of electrical sheet steel in the magnetic circuits and 8 tons the weight of copper used in the windings. The heaviest parts packed for shipment were the sections of the stators, each section weighing approximately 14 tons gross. The heaviest lifts to be handled in erection were the complete stator weighing 54 tons and the rotor weighing 56 tons alone, or 75 tons with the water-wheel runner.

A NEW coalfield which has been discovered in the Dutch East Indies is estimated to contain ten million tons of good quality coal.

Some Experimental Results from a Three-cylinder Compound Locomotive.*

By LAWFORD H. FRY, Member, of Burnham, Pa., U.S.A.

THE main purpose of this paper is to study, by means of experimental data, some phases of the cylinder action of a three-cylinder locomotive using a boiler pressure of 350 lb. per square inch. This locomotive was built as an experiment by the Baldwin Locomotive Works in 1926 under Serial No. 60,000. After a thorough series of tests on the Pennsylvania Railroad locomotive testing plant at Altoona it has been tried in road service on a number of important railways in the United States with very satisfactory results.

Tendencies in American Locomotive Design.—The design of locomotive No. 60,000 is novel and is of interest, not only intrinsically, but also as evidence of the attempt being made by present-day American designers to improve the steam locomotive. A word on tendencies in steam locomotive design is in order before dealing with details of the example that forms the main subject of the paper. Two papers† read recently before the Institution dealt fully with the economic advances made by the use of high steam pressures in stationary and marine prime mover practice, but neglected the steam locomotive almost entirely. In fact such mention as was made left the impression that locomotive design was at a standstill and that the steam locomotive was almost moribund. This is by no means the case. A review of locomotive design during the past twenty years will show a general and continued improvement in locomotive efficiency with particular activity in this direction at the present time.

Some figures in support, taken from American practice as most accessible to the author, are quoted below. During the past twenty years, growth in the size of the power unit has increased the operating efficiency of the railways, and this has also been accompanied and supplemented by an increase in the actual locomotive efficiency. Figures illustrating the increase in weight, horse-power and the improvement in coal consumption follow. These are taken from freight locomotives tested under similar conditions and are representative of the periods to which they are assigned except in the case of the 4–10–2 type which is the experimental high-pressure locomotive described in the paper.

Loco. type.	Year built.	Loco. weight, lb.	Maximum I.H.P.	Coal fired, lb. per hour.	I.H.P. per 1000 lb. of loco. weight.	Coal per I.H.P. per hr., lb.
2–8–0	1904	175,000	1,000	4,500	5·7	4·5
2–10–0	1923	386,000	3,530	12,800	9·1	3·6
4–10–2	1926	457,000	4,500	11,500	9·9	2·6

Of these three locomotives, that of the year 1904 was of the two-cylinder single-expansion type using saturated steam at 205 lb. per square inch ; the engine of 1923 also had two cylinders but used superheated steam at 250 lb. per square inch and had a limited cut-off. The third and latest is the three-cylinder compound with 350 lb. per square inch boiler pressure which is dealt with in the present paper.

Improvement in efficiency is shown, not only by individual tests, but also by operating statistics. This year the Committee on Utilisation of Locomotives reported to the American Railway Association average figures obtained in a field survey of thirteen important American railways. In 1922 the coal required to haul 1000 tons, of 2000 lb. each, of freight and equipment exclusive of locomotive and tender was 186·0 lb. per mile. This was reduced progressively each year until it was brought down to 154·8 lb. in 1926, a 16·8 per cent. reduction in four years. This reduction in coal consumption was effected in spite of the fact that the average road speed of freight trains was increased by 7·2 per cent. At the same time the average freight train weight was increased by 18·6 per cent., so that the ton-miles per train hour were increased by 27·9 per cent. These increases in power and efficiency, while in part due to better utilisation of the locomotives, are largely the direct result of the introduction of heavier and more efficient locomotives. Superheating has become general, feed-water heating is widely used, the design of cylinders and boilers has received much attention, and at the present time American locomotive designers are giving particular attention to the problem of making still further advances.

High Steam Pressures.—Increased boiler pressure appears to offer an excellent opportunity for greater efficiency. Pressures of 240 lb. and 250 lb. per square inch are widely used. The New York, New Haven and Hartford Railroad is experimenting with locomotives using 265 lb. per square inch, the Delaware and Hudson has two locomotives with 350 lb. and 400 lb. per square inch respectively, and the Baldwin Locomotive Works has built for experiment locomotive No. 60,000 with 350 lb. per square inch. Several other railways have under consideration or in process of design locomotives in which pressures of 450 lb. and 500 lb. per square inch are contemplated.

The success with which such pressures have been used in stationary practice suggests the possibility of considerable economy in locomotive work, but the special conditions of the service introduce certain limitations not met with in stationary practice. To secure the full benefit of high steam pressures a high ratio of expansion is required. This is obtained in stationary prime movers by the use of steam turbines and condensers. Several experimental turbine locomotives using condensers have been built and appear to have achieved a *succès d'estime*, but there is as yet no indication that they will offer serious competition to the reciprocating engine. Fuel consumption is reported as remarkably low, but against this must be set high first cost and a large amount of complicated and delicate mechanism, amongst which must be some form of transmission gear. The reciprocating engine exhausting to the air and directly connected to the driving wheels possesses, for locomotive work, many inherent practical advantages of

* The Institution of Mechanical Engineers. Dec. 16, 1927.
† "Proc.," I. Mech. E., 1927, Vol. i., pages 53 and 99.

which simplicity is not the least. It is capable of still further improvement to secure higher efficiency, and until such improvement has been carried to the furthest possible point the reciprocating engine must be considered to have a good lease of life. The necessity for mobility handicaps the locomotive designer still further in providing for the generation of steam. The fire-tube boiler with rectangular fire-box established by the first President of the Institution, George Stephenson, has held its own for nearly one hundred years. For pressures in excess of 250 lb. per square inch the flat stayed surfaces of the fire-box will

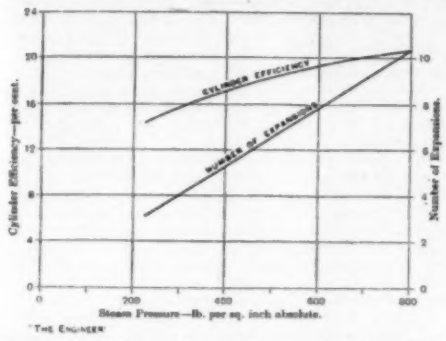


FIG. 1—*Relation Between Steam Pressure, Maximum Cylinder Efficiency, and Ratio of Expansion.*

Conditions assumed :—
Steam temperature, 650 deg. Fah.
Adiabatic expansion.
Release pressure, 50 lb. per square inch absolute.
Exhaust pressure, 25 lb. per square inch absolute.

probably give way to some form of water-tube fire-box construction, but the fire-tube barrel can hardly be improved upon. This type of boiler barrel is not only effective as a steam producer, but provides an important structural element of the locomotive.

For the present, therefore, it appears probable that the high-pressure locomotive will develop with a boiler having a fire-tube barrel and water-tube fire-box, and that the steam will be used in a reciprocating engine with exhaust to the atmosphere after a relatively long expansion. These figures were obtained by assuming that at all pressures the steam has 650 deg. Fah. of superheat at admission, that the steam enters at full admission pressure up to the point of cut-off, that expansion takes place adiabatically down to a release pressure of 35 lb. per square inch—50 lb. per square inch abs.—and is then released to and exhausted at a pressure of 10 lb. per square inch above the atmosphere. The relation between steam pressure, ratio of expansion and the theoretical cylinder efficiency obtainable under the above conditions is shown graphically in Fig. 1. The thermal efficiency is seen to rise as the steam pressure is increased, but the ratio of expansion

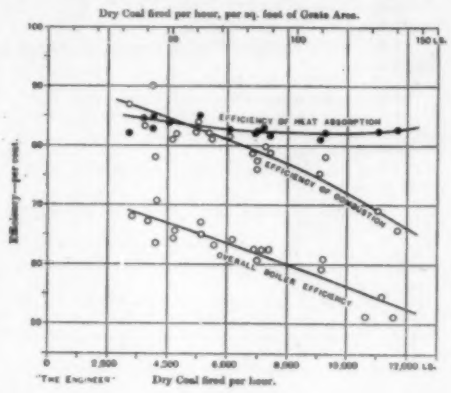

Dry Coal fired per hour, per sq. foot of Grate Area.
EFFICIENCY OF HEAT ABSORPTION
EFFICIENCY OF COMBUSTION
OVERALL BOILER EFFICIENCY
Efficiency—per cent.
"THE ENGINEER"
Dry Coal fired per hour.

FIG. 5

necessary for this efficiency rises even more rapidly, particularly as the higher pressures are reached. This necessity for higher expansion imposed by the higher pressures introduces difficulties in locomotive practice. With single-expansion cylinders it means special valve gears, large cylinders and considerable variation in torque, and while compounding eases some of these difficulties, it involves at the same time a larger number of cylinders and moving parts. Increased boiler pressures also entail additional difficulty in the construction and maintenance of the

FIG. 2—THREE-CYLINDER COMPOUND LOCOMOTIVE NO. 60,800

With this type of boiler the degree of superheat will, irrespective of pressure, probably not differ greatly from that now used, say, from 600 deg. to 700 deg. Fah.

This limit of steam temperature and the fact that exhaust must be atmospheric will determine the cylinder efficiency that it is possible to obtain with any steam pressure. The question was discussed in a paper presented by the author to the American Society of Mechanical Engineers in May, 1927, in which the following figures

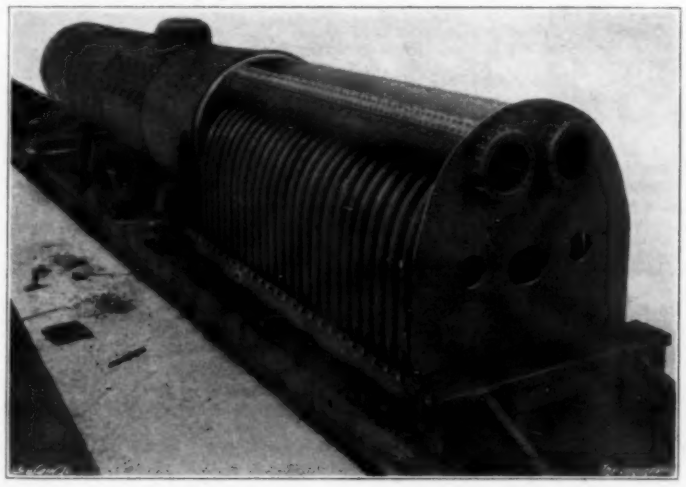


FIG. 3—BOILER OF NO. 60,000

were given for the highest theoretically possible cylinder efficiencies at various steam pressures :—

Admission pressure, lb. per sq. in. gauge.	Number of expansions.	Heat transformed to work, B.Th.U. per lb.	Thermal efficiency, per cent.	Relative efficiencies.		
205	3·12	191	14·2	100	—	—
335	4·60	222	16·6	117	100	—
435	5·85	238	17·9	126	108	100
585	7·78	255	19·3	136	116	108
785	10·35	270	20·7	146	125	116

boiler. It follows that both engine and boiler tend to limit the steam pressure, and it seems probable that at least for the present the most economical pressure when construction, operation and maintenance are considered will be found not to exceed 500 lb. per square inch.

Locomotive No. 60,000.—The general appearance of the locomotive is shown in Fig. 2. It is of the 4–10–2 type and presents no striking novelty in external appearance. The boiler, shown in Fig. 3, has a fire-tube barrel of conventional design, while the fire-box is of modified Brotan design, with the side walls formed of bent 4in. tubes running from a hollow water space frame at the bottom to two 26in. drums at the top. The front and back fire-box walls are of fire-brick, and a shell of fire-brick cased with magnesia-lagged steel jacket sheets encloses the water tube side walls and drums. The three compound cylinders, 27in. by 32in., are cast in one piece with three valve chests and the boiler saddle, Fig. 4. The middle cylinder, which is the high-pressure cylinder, drives the front coupled axle by a crank between the frames, set at 135 deg. to the two outside cranks on the second coupled axle, which are driven by the low-pressure cylinders. Each of the three piston valves is driven by a separate valve gear, but all gears are operated by a single power reverse gear so that the relation between the events in the high and the low-pressure cylinders is fixed in advance for each cut-off.

Before locomotive No. 60,000 went into road service it was very thoroughly tested on the locomotive testing plant of the Pennsylvania Railroad. Full particulars of the results obtained have been made available for publication through the courtesy of Mr. J. T. Wallis, Assistant Vice-President, and Mr. F. W. Hankins, Chief of Motive Power. For the purpose of this paper attention is directed in greater detail to the cylinder action, but a few notes as to the operation of the boiler are desirable to complete the picture.

Boiler Efficiency.—Fig. 5 shows the overall boiler efficiency, the efficiency of combustion and the efficiency of heat absorption, in relation to the rate of firing.

The overall boiler efficiency is the heat utilised in the boiler exclusive of the feed-water heater, in producing and superheating the steam, expressed as a percentage of the heating value of the coal fired.

The efficiency of combustion is the heat produced in the fire-box expressed as a percentage of the heating value of the coal fired.

The efficiency of heat absorption is the heat taken up by the heating and superheating surfaces, expressed as a percentage of the heat produced by combustion. The heat absorbed includes that lost from the boiler by external radiation which is taken to be 5 per cent. of the heat utilised by the boiler. Consequently at any given rate of operation the product of the efficiencies of combustion and absorption is 5 per cent. greater than the value for the overall efficiency. From Fig. 5 it is seen that the overall boiler efficiency ranges from about 70 per cent. when 30 lb. of coal is fired per square foot of grate per hour to about 52 per cent. at the maximum rate of firing, which was 135 lb. per square foot per hour. The efficiency of heat absorption is not greatly influenced by the rate of operation, ranging only from about 85 per cent. at low rates to about 83 per cent. at high rates. The efficiency of combustion, on the other hand, ranges from about 87 per cent. to about 67 per cent. when the rate of firing is increased from 50 lb. to 135 lb. per square foot of grate area per hour. Combustion is evidently the major factor in determining the overall boiler efficiency.

The coal used had an average heating value of about 13,700 B.Th.U. per pound, and the following proximate analysis :—

	Per cent.
Fixed carbon	57·9
Volatile matter	31·8
Moisture, combined	0·7
Ash	9·6
	100·0

The values found for the overall boiler efficiency do not differ materially from those to be expected from a well-designed boiler of conventional design. The values for the efficiency of combustion are good, which is doubtless due to the large fire-box volume, 8·3 cubic feet per square foot of grate.

Measurements made of the temperature of the gases at the fire-box tube plate permit an estimate of the proportions in which heat is absorbed by the fire-box surface, by the fire-tube heating surface and by the superheater. These proportions remain, as shown by the figures below, very nearly constant for all rates of evaporation.

Water evaporated per hour	30,000 lb.		60,000 lb.	
Heat taken up per hour—	B.Th.U.	Per cent.	B.Th.U.	Per cent.
By fire-box	14,200,000	37·5	28,200,000	37·0
By flues	20,000,000	53·0	38,800,000	51·5
By superheater	3,600,000	9·5	8,800,000	11·5
Total	37,800,000	100·0	75,800,000	100·0

The heating surfaces through which the heat is transmitted

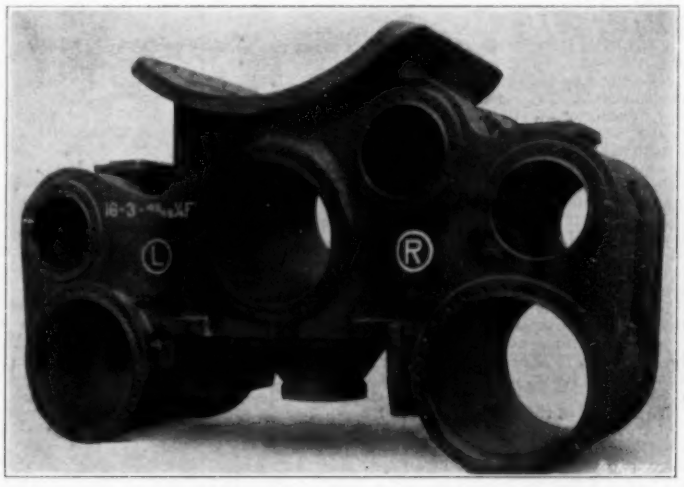


FIG. 4—CYLINDER CASTING OF NO. 60,000

and the rate of heat transfer per square foot of surface per hour are as shown below :—

Water evaporated per hour	30,000 lb.	60,000 lb.
	Surface.	Heat transfer per sq. ft. per hour.
Fire-box	357 sq. ft.	39,500 B.Th.U.	79,000 B.Th.U.
Flues	4,420 sq. ft.	4,500 B.Th.U.	8,750 B.Th.U.
Superheater	1,357 sq. ft.	2,650 B.Th.U.	6,500 B.Th.U.

These figures are based on the outside diameter of the boiler flues and the inside diameter of the superheater tubes. The area of the fire-box is the approximate projected area, of which about 60 per cent. is in the fire-box proper and about 40 per cent. in the combustion chamber ahead of the fire-brick arch. It also includes 27 square

feet of arch tube surface. The projected area of the fire-box is about 330 square feet, while the total area of the side wall tubes and the area of the drums exposed to the fire amounts to 745 square feet.

(To be continued.)

The Federation of Engineering Societies.

SINCE a leading article under the heading which we use above, appeared—see THE ENGINEER, December 16th—we have received from Mr. J. H. Barker, the full text of his admirable address to the Yorkshire Branch of the Institution of Mechanical Engineers. From it we extract that portion which deals with the question of the unification of the proceedings of engineering societies.

The time allotted to a chairman's address is quite exhausted, but a little further indulgence is craved to try and learn from the dream of the great Chancellor and the performance of the Association under review some lesson for the Institution represented by this evening's meeting.

The great Francis Bacon set forth an ideal which should be the aim of every scientific society; not only the dissemination of true knowledge, but the recording of knowledge in such a form that it is accessible to all with the minimum expenditure of time, trouble, and expense.

The Royal Society, founded in 1660, the Society of Arts in 1754, and the British Association in 1831, have all for their object the spread of learning in almost every form. The first has two and a-half centuries' experience, the second over a century and a-half, and the last nearly a century; yet, so far as can be seen, each disseminates the same subjects and each accumulates records without paying much regard to the others.

Perhaps it is too much to expect a single society to take charge of all subjects, but it were worthy of consideration whether, say, an engineering society could not achieve such unification in respect of engineering associations. Let reference be made to one publication, which is an excellent example of the collecting of invaluable information on nearly every subject—"Whitaker's Almanack," now in its fifty-ninth year. Therein are tabulated over one thousand societies, beginning with the British Academy—President, Earl of Balfour—and ending with the Young Socialists' League. The accountants have no less than nine; societies dealing with engineering number fifty-five, the great majority having their headquarters in London, and doubtless the greater number printing "Proceedings" which could be better edited and compiled under a single department and tabulated in accessible form.

Many members of the Institution represented by this gathering belong to the other two leading engineering societies, each of which publishes 10,000 copies of its "Proceedings" each year, in at least four parts, or a total annual issue of 120,000 volumes. The speaker himself possesses no less than 150 volumes of one society alone, and to these he does not refer a dozen times in a year. The subscriptions to these three societies must be in the range of £100,000 per annum, when perhaps half the amount could furnish a more efficient service, leaving the balance to devote to research or other worthy object in need of support.

Side by side in Great George-street and Storey's-gate, each equipped with lecture theatre, library and other offices, are two institutions each capable of ministering to all the needs of both. Both are deserted during nearly the whole of the year. There is a third institution, boasting larger membership than either, with, it is believed, equally palatial buildings, but although the speaker has belonged to it for thirty years, he has never been inside the premises. And what of the remaining fifty-two engineering societies?

And the remedy? Three old and justly famous institutions have failed to unify, probably because the thing aimed at was too high to attain at once.

The first step is to study human nature, which is almost unchangeable. Regard it as unalterable as C.G.S., itself: Self, Self-interest, Self-preservation, Self-advancement, Self-enrichment! An ill day it will be for the race when human nature departs from these basic principles. This is as fundamental, awful and humiliating as the other axiom that the foundation of all life-forms is the death of other life-forms.

It were well to recognise all this, but likewise to recall the history of science, especially the engineer's science; that for every ill there is a cure, or, at any rate, a palliative, and when the time is ripe the means are at hand. The remedy for the ill of self-interest is the realisation that the interest of each is dependent on the interest of the rest, that self-advancement should not mean the degradation of the other man, nor his displacement, but that whilst lifting the self to higher things, greater riches, and increased honours, the lower, or even the displaced man, should be raised too.

To what does this peroration lead?

All successful unions, whether they be of kingdoms, counties, cities, towns, companies or even societies, must have as a basis the interest of all concerned. In a company, the directors, the shareholders, the customers and the staff; in a society, the officers, the members and the staff. In each of the two instances just mentioned the staff rightly have the greatest self-interest, and on them the success of any amalgamation does and should depend.

In this wild dream of the union of fifty-five societies one short-sighted anticipated result would be the reduction to a single secretary. True, but likewise the creation of double the number of fifty-four better posts to absorb those displaced, and as the progress of such a union would be slow, the disturbance of staff would be small. All the same, the first principle of any amalgamation must be the undertaking that every worthy member of staff would benefit and not suffer.

To subscribing members the reward promised should not be a reduction in cost, but better value for the same money—not only personal direct value, but value to all. To the officers, from the President downwards, the honour and responsibility of a single section of the combination should rank even higher than the presidency of any single institution, and there should, above all, be the creation of the new office of General President, whose rank should be set forth in a new charter.

How to begin! First have the end in view, to amalgamate all societies kindred to engineering.

Next fix the first step, and leave the second to abide the results of the first.

A suitable first step would be to form an Editing Committee of a few of the larger societies, say of the Great Three.

Divide the combined "Proceedings" into suitable groups, say:—

(1) Railways, Bridges, Docks, Canals, Harbours and Roads.
(2) Locomotives and Rolling Stock.
(3) Electrical Generation and Distribution.
(4) Naval Architecture and Marine Propulsion.
(5) Internal Combustion Engines.
(6) Land Propulsion.
(7) The vast field of mechanical engineering in all other directions.

No. 7 would obviously be divided and subdivided as occasion required.

Each member of a society might receive volumes relating to two sections gratis and other volumes at cost price.

The Committee might consist of members of the Council of each Institution and a number of highly trained paid experts, one for each section, and the chairman appointed by each Institution in rotation for a period.

Such a beginning could not in any way interfere with the prestige of any of the Institutions; it could not be derogatory to the dignity of the oldest and most exclusive to accept information from the youngest and largest, and the convenience and the improved efficiency of collected "Proceedings" would be a reward in itself.

A beginning such as this could have but one end, the gradual uniting of societies, their buildings, libraries, lectures and educational facilities open in some measure to all.

The idea of union is by no means new; the difficulties and dangers are many; the proceedings to effect it must be slow. Let the first step be one with the fewest stumbling blocks, and the uniting and combining of accumulated knowledge can surely offer a line of least resistance.

It must be distinctly understood that this "prospect" is an expression of a personal opinion and a desire on the part of the speaker, having no official inspiration or sanction of the Institution of Mechanical Engineers or its Council. Be it noted, however, that in the Council of the said Institution, consisting of forty-two members, no less than twenty-four are also members of the Institution of Civil Engineers—a majority, in fact. There are likewise seven who are members of the Institution of Electrical Engineers. Could any circumstance more clearly demonstrate or more loudly proclaim the common interest? Similarly, on the Council of the Institution of Civil Engineers there are ten members of the Institution of Mechanical Engineers and an equal number on that of the Institution of Electrical Engineers. As student, associate member and member, the speaker has subscribed to the Institution of Civil Engineers for forty years; he has likewise been a member of the Institution of Electrical Engineers for thirty.

A South African Hydro-Electric Plant.

So much has been written within recent times of vast hydro-electric schemes, with outputs of hundreds of thousands of horse-power, that some of the smaller developments, which have involved no less ingenuity in their design and construction, have been left in comparative oblivion. In the circumstances the following account of a small but peculiar development in South Africa is interesting as exemplifying how water power may be turned to advantage where coal or other fuel is costly. The following notes are an abridgment, made by the *South African Engineer*, of a paper read before the South African Institute of Electrical Engineers by Mr. A. M. Jacobs, Chief Engineer of the Electricity Supply Commission. The plant described is on the Sabie River in the Lydenburg district of the Transvaal, and was the first to be completely designed by the Commission's own engineers. It presented numerous problems requiring as much thought and application for their solution as though it had been many times as large.

Power had previously been generated for the service of the gold mines in the neighbourhood of Sabie by a turbine station at the Sabie Falls, supplemented by a Pelton wheel unit on Rietfontein Spruit, and for a considerable time past demand had been greater than supply. When the problem of increasing the supply was studied it was evident that an undertaking sufficient to meet the revised estimates could be started at Inaccessible Gorge, some 6 miles downstream from the Sabie Falls.

The works carried out by the Commission comprise the dam and intake works; the system for conveying water to the power station, including three tunnels, lined open cut, two aqueducts, sand trap, syphons, head box, and pipe line; the power station with outdoor high-tension switchgear; the 22,000-volt transmission line and the telephone line; the sub-station with outdoor high-tension switchgear at Sabie township; 2¼ miles of 3300-volt distribution line at Sabie; 6 miles of road for transporting machinery to the head of the runway, which was used for lowering equipment to the pipe line and the power station; and three houses for European operators at the generating end, with a domestic water supply.

The system has been designed for generating 900 kW all the year round, *i.e.*, under the worst conditions of flow which can be anticipated. From the data available it is estimated that a flow of 70 cusecs can be relied upon year in and year out at the intake. The gross head obtained at minimum river level at the power station is 207ft.

The site finally chosen for the dam is situated about 4000ft. upstream from the Inaccessible Gorge. A series of rapids occurs immediately below the dam and at points intermediate between the dam and the Gorge.

On account of the river being used as a repository for the tailings of the mines around Sabie, it was not considered desirable to contemplate any storage of water. A storage dam would inevitably be silted up very rapidly, hence the sole purpose of the dam is to secure the necessary head and to divert the water into the intake works.

The dam and intake were constructed of concrete and are of the gravity section type. From information available it would appear that at maximum flood the flow of the river may rise to approximately 13,000 cusecs. With a spillway length of 160ft. the head of water over the crest would be about 8½ft., and the comparatively low dam was therefore given a massive cross section.

The right wing of the dam and the whole footing are tied into solid rock. Conditions on the left wing were not so favourable, and a core wall had to be carried a considerable distance into the left bank.

The intake could not be arranged at right angles to the flow of the river, and a channel was therefore cut to a point immediately in front of the intake openings, where a 40in. scour valve was fitted, which will remain open as long as the loss of water can be permitted, and will remove the coarser solids brought down by the river. The openings lead into an intake basin provided with two vertical trash racks and two gates, and two scour valves for passing out any coarse solids which may settle there.

In place of automatic regulating gates, syphons are provided, as mentioned below, to prevent overflows along the waterway.

From the intake basin the water flows into a tunnel 7ft. by 6ft. in section and 1980ft. long with a slope of 1 in 700. The extra slope, as compared with later sections of the waterways (1 in 1000), was given to prevent silting, the sand trap being placed near the exit from this tunnel. The formation pierced by this tunnel was good, and only 48ft. required lining, the rest being left bare. The sand trap, which comes next, is 97ft. long and 120 square feet in cross section. The silt drops into flushing ducts, covered by perforated planks, and is removed through scour valves at the lower end of the trap.

A canal 1200ft. long, cut in decomposed granite incapable of holding water, follows. This section was therefore lined with 3in. of concrete. It contains two aqueducts, one, in reinforced concrete, 160ft. long with a maximum height of 34ft. The next section consists of a second tunnel 1520ft. long, followed by a short trough 70ft. long, and a third tunnel 950ft. long, which leads into the head box. The tunnels were all driven by compressed air, furnished by portable compressors set up midway between the first and second tunnels. The head box acts to some extent as a settling basin, and is provided at the deep end with a 12in. scour valve. A 52in. valve and bell-mouthed transition connect the head box with the 42in. penstock.

The pipe line was designed to carry 70 cusecs normally and 90 cusecs on overload. It consists of 541ft. of straight run, followed by a horizontal bend just ahead of the turbine manifold, and is made up of steel tubes in 24ft. lengths, with butt-welded longitudinal joints and section joints of the butt and strap type, with the straps welded on. Thicknesses vary from ⅜in. through ⅝in. to ¾in. Four expansion joints of the sliding sleeve type are provided, also manholes for access and an air vent at the upper end rising above the level of the head box. The pipe line is carried on concrete piers and is anchored by means of collars and straps attached to the heavy bolts carried in the anchor blocks. At supporting piers the pipe rests on asphalted sheets to facilitate sliding movement. The manifold is provided with three 27in. branches to the turbine valves and with a 12in. flushing valve at the end. The hand wheel of the flushing valve is in the machine room, so as to enable the operator, in case of emergency, to waste the water in the pipe. The pipe line manifold and expansion joints were built locally, electric welding being employed, and a pressure test at 160 lb. per square inch was successfully carried out after erection.

Three spiral casing reaction turbines (James Gordon) direct coupled to three-phase A.S.E.A. alternators and exciters are erected in the machine room. The wheels are rated at 688 H.P. each, with 35 cusecs passing at a head of 201·5ft. The overload rating with 45 cusecs is 835 H.P., the head being reduced to 195ft. The machines run at 750 r.p.m. The runners are of bronze and all wearing parts are replaceable. A fly-wheel weighing 2800 lb. is mounted between the turbine and alternator. The units are controlled by belt-driven oil-pressure governors with runaway trips. The generators are of the open type, rated at 600 kVA, 3300 volts, 50 periods, and are fitted with temperature detectors at four points in each machine, connected to a multipoint indicator on the switchboard.

The 3300-volt switchgear is of the remote hand-operated indoor cubicle type, while all the 22,000-volt gear is of the outdoor type. The indoor circuit breakers are mounted in concrete cubicles having metal doors consisting of a sheet iron panel with expanded metal above. The 3300-volt bus-bars are protected by sensitive indoor type arresters. The step-up transformers comprise a bank of 400 kVA single-phase transformers connected delta star, with the e.h.t. neutral point grounded through a reactance. A spare single-phase unit is provided ready for emergencies.

The arrangements in this connection may be of interest. In line with the blocks for the three running transformers a fourth block has been provided, opposite which, on the other side of the transfer track, is the block carrying the spare transformer. The replacement of a defective transformer is carried out by running it on to the transfer trolley, which is then pushed into position opposite the vacant block that then receives the unit; the spare transformer is run on to the trolley and carried to the site vacated by the defective unit. After connecting up the spare to the conductors and the expansion vessel the damaged unit can be put on the trolley again and run through the workshop on to the platform in the machine room, where the crane is available for lifting out the core and windings.

Switching is done on the low tension side. As there is only one transmission line leaving the station no 22,000-volt oil circuit breaker has been installed, but the layout permits of two such breakers being put in should an extra 22,000-volt line be required in future. The outdoor switchgear is very simple, consisting merely of a disconnecting switch for isolating the power station from the

line, a grounding switch for the line, and a disconnecting switch for the lightning arresters which are of the horn gap and oil immersed damping resistance type.

Station lighting is obtained from a small step-down transformer, but for emergencies there has been installed a paraffin engine driven direct-current generator of 4 kW, the lighting leads being so arranged that by operating a throw-over switch the lights can be connected to the direct-current circuit. For measuring the flow to the turbines there is an Electroflo meter for indicating and graphing instantaneous values, and for integrating the total volume of water.

The Commission's transmission line is roughly seven miles long and runs over broken country. The pin type insulators were supplied by Bullers, Ltd., and are designed for a dry flash-over of 150 kilovolts, wet flash-over 110 kilovolts. The copper cross-section is 0·06 square inch stranded. Spacing is 36in. horizontal, except at transposition points, of which there are two, giving one complete barrel on the line. The poles are 35ft. long, solid drawn, tubular type and are treated with anti-rusting compound inside and out. Metal base plates are not used. The poles were given a large "dollop" of concrete before upending, and tarred sacking was tied over the open end. A 12in. diameter by 4in. thick concrete biscuit provides the pole base. The depth in the ground is 5·5ft. A ⅜in. diameter steel ground wire is carried at a distance of 4ft. below the power wires, and below it again comes the phosphor bronze, metallic return, telephone line. The average span is 250ft., the maximum span 330ft. The worst conditions to be met are imposed by low temperature. The line was calculated for a stress of 22,500 lb. per square inch in the power conductors at a temperature of 25 deg. Fah. Strain poles are provided at intervals of 2600ft. All angle poles are strain poles. These poles are equipped with disc insulators, four in a string. The telephone line is transposed in such a way as to secure excellent speech transmission under all operating conditions. The ground wire was earthed efficiently at several points along the route; in fact, wherever permanently moist soil could be found.

The receiving and distributing station adjacent to the Glynn's Lydenburg, Ltd., plant contains a bank of 250 kVA step-down transformers similar to those at the power station except that the e.h.t. neutral is not earthed. There are two e.h.t. lines, the incoming from the station and an outgoing to Elandsdrift, and these are protected by hour arresters with series resistances, while the latter line and the step-down transformers have hand-operated circuit breakers. The low-tension voltage is 3300 and the switchgear is similar to that at the power station. Provision has been made for four outgoing lines at 3300 volts, and two are at present in use, one to Glynn's Lydenburg and one to the New Sabie G.M.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Seasonal Quietude.

FEW transactions of any note were negotiated at the weekly meeting of the Midland Iron Trade in Birmingham to-day. The market was poorly attended, and the tone was somewhat slack, as it usually is at this season. In nearly all the branches of iron and steel raw material purchases have been completed for the year, and there is no inducement offered considered sufficiently good to encourage consumers to buy for the New Year. A few conversations as to possible forward contracts took place, but they did not lead to business. Little, if anything, is expected from next week's meeting, and iron and steel-masters are now in a position to assert that the last quarter of the year 1927 has proved a decidedly disappointing one. Optimistically, they are looking forward to 1928, trusting it will show a vast improvement on the year now so near its close.

Raw Iron.

Purchases of pig iron for this year are now almost at an end, consumers having sufficient material to enable them to finish up for the Christmas holiday and with which to restart. On 'Change in Birmingham to-day business was decidedly quiet. Some conversation regarding German supplies took place but it did not lead to business. Smelters were unwilling to go below £3 5s. for Derbyshire foundry and £3 0s. 6d. for Northampton, claiming that these prices are barely remunerative. Consumers, however, contended that values should be further reduced, and expressed their disinclination to purchase forward unless better terms were forthcoming. They have no fear as to future supplies, maintaining that, in spite of the curtailment of production, there is still more than enough pig iron being produced to supply users' current needs. The output throughout the country, they note, in November fell to 575,900 tons, but this total is considered higher than was to be expected with seven fewer active furnaces. Of late there has been some improvement at the heavy foundries, and it is anticipated that in the new year much more business will be forthcoming so that orders for foundry pig should be considerably more numerous. The forges are poorly off for work, and little of this material has been purchased of late, though supplies of Derbyshire make have been obtainable at as low as £2 19s., and Northamptonshire at £2 14s. 6d. There is small prospect at the moment of any marked recovery in this department.

Finished Iron.

The finished iron trade remains unchanged as regards demand and prices. The trade is benefiting somewhat, however, from improving conditions in shipbuilding and engineering. Marked bars continue at £13 per ton. The pronounced disparity in the quotations of Crown iron continues. Staffordshire houses continue to quote £10 5s. to £10 10s., but makes from outside districts are offered at from £9 5s. upwards. Very few sales of nut and bolt and fencing bars are being made by Staffordshire ironmasters, consumers contending that the price is far too high. Practically all their requirements are being met by Belgian mills, which are prepared to deliver to the Black Country at very little more than half the price quoted by local makers. There is, if anything, a slightly better inquiry for iron strip, some of the tube makers being a little busier. Values remain stationary, however, at £11 10s. per ton. Considering that a reaction in favour of Staffordshire iron for tube-making is setting in, several of the largest tube works in the Black Country are said to be extending and renovating their plants in readiness for improved business. Staffordshire ironmasters have had a poor year, and it is now too late to make any headway. Attention is therefore being concentrated on the New Year. Many of the ironworks will have an extended holiday, and stocktaking will in many instances be completed before the works resume.

Steel.

Steel mills are operating on a moderate scale, new business being scarce and keenly competed for. Rolling stock work is providing a useful standby. Constructional steel is offered at recent rates. Some of the users report rather more activity in the yards of the Black Country, but the general complaint is that prices are being severely cut. Values of small bars rerolled from foreign material continue to weaken. Business has been done this week at as low as £7 7s. 6d., but many Staffordshire rollers ask £7 10s. Even this figure, however, is half a-crown below recent quotations. All British bars are also slightly easier in price, £7 17s. 6d. having been pretty generally accepted. Few sellers this week asked the full price of £8. The improved conditions in the Welsh tin-plate trade have resulted in dearer billets. Welsh mills this week wanted fully £6 per ton, an advance of 5s. on recent terms. Local users displayed no eagerness to buy at this figure. Midland steelworks will in some cases have a full week's holiday for Christmas, but in others work will be resumed at mid-week.

Galvanised Sheets.

Demand for galvanised sheets continues disappointing, though there has been slightly more call from users at home during the past week. The action of many mills in reducing quotations a further 2s. 6d. per ton, bringing the selling figure of 24-gauge corrugated to £13 2s. 6d., possibly accounts for the improved home demand for many merchants and consumers of sheets are under the impression that a turn in the tide in this department is approaching, and they consider it wise to buy while prices are at their present low level. Overseas consumers still withhold orders, notwithstanding the circumstance that this week some of the large mills have offered supplies of 24-gauge at £13 f.o.b. It is stated on 'Change in Birmingham to-day that a few orders have been placed on account of South Africa and South America, but they are not enough to put any life into the market. Wasters are in relatively better demand than primes, and the difference in price is only about 5s.

Feared Effect of German Lock-out.

There was considerable discussion on 'Change to-day as to whether the threatened labour trouble in Germany will make any appreciable difference to the British market. It is realised that the German iron and steel workers' fight for a higher standard of wages may result in serious difficulty for local users of German material. It was stated to-day by Birmingham importing merchants that many producers in Germany have withdrawn quotations, and there is a distinct tendency on the part of makers in Belgium to stiffen quotations. So far as buying and selling to-day were concerned, there was not much indication of tension, and consumers betrayed but little anxiety to negotiate. Belgian billets were offered at £5 6s., and blooms at £5 to £5 2s. 6d. A good deal of German steel strip, has recently been imported to the Black Country for the making of gas and steam tubes, and though works are at the moment fairly well placed for material, a protracted lock-out would cause them, to say the least of it, considerable inconvenience. Local users of foreign material are under the impression that industrial trouble in Germany would certainly have the effect of substantially reducing importations of iron and steel from other continental countries to Britain.

Production Figures.

The monthly iron and steel production returns show that the output of pig iron in November amounted to 575,900 tons, compared with 596,300 tons in October and 591,500 tons in September. The production includes 190,500 tons of hematite, 184,300 tons of basic, 152,200 tons of foundry, and 27,800 tons of forge pig iron. The production of steel ingots and castings amounted to 698,700 tons in November, compared with 699,000 tons in October and 777,000 tons in September. It is unfortunate that the output of iron and steel had during the month to be further reduced to maintain the balance between supply and demand, ten furnaces having stopped against three rekindled. The total number in blast throughout the Kingdom is now 155, as compared with 184 at the end of May.

Midlands Area Coal Control Scheme.

A big coal scheme for the Midlands federated area—namely, Yorkshire, Nottinghamshire and Derbyshire—for rationing of output and regulating prices is now expected to be approved by all the areas concerned. Among the features of the scheme is a levy on all coal raised, with a maximum of 3d. per ton to work the scheme and assist the export trade. By this scheme it is hoped to reduce the cost of coal for abroad by 3s. per ton. Output is to be regulated according to demand, each colliery having its quota fixed by a special committee. It is proposed to impose a penalty of 3s. per ton on members found guilty of over-production above 1 per cent. A provision is made that the Council of the Central Association shall consist of members appointed by each district, and the various committees to operate the scheme will have independent chairmen. It is interesting to note that the output from the three counties is 75,000,000 tons a year—one-third of the whole of Great Britain's production—as against the 45,000,000 tons covered by the recent agreement reached by the owners in South Wales. Moreover an invitation has been extended to the rest of the Midland coalowners including Cannock Chase to join in the scheme, and there is every possibility that, should it be adopted, the Cannock Chase colliery owners will be parties to the compact. In the report covering the scheme the committee points out that most drastic action is necessary in order to put the industry on a paying basis, and to revive the export trade. An appeal is made to the loyalty of all members to abide by all the suggestions, and it is proposed that the scheme should operate early in the New Year.

Unemployment.

Unemployment in the Midlands has decreased steadily during the last few weeks, and in the current return there is a substantial drop, the total of 127,819 being less by 5573 than it was in the previous return. In the Birmingham area the total has fallen from 22,607 to 21,815; Coventry from 3866 to 3846; Wolverhampton from 3939 to 3793; Oldbury, from 892 to 858; Smethwick from 2743 to 2694; Bilston, 2053 to 1997; Stourbridge and Brierley Hill from 2420 to 2341; Tipton from 1583 to 1538; Walsall from 4315 to 4232. At West Bromwich, Wednesbury, Dudley and Cradley Heath there have been light increases, while in the Stoke-on-Trent area the figures have advanced from 16,062 to 17,036.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Exports of Textile Machinery.

THE British textile machinery industry last month shared in the general improvement in foreign trade, for shipments to overseas markets under this heading during November reached the highest value of any previous month this year. In quantity the exports during the period under review amounted to 13,301 tons, compared with 9679 tons and 10,790 tons in the corresponding months of the two previous years, the total value being £1,281,044, against £947,766 in November, 1926, and £1,015,530 in 1925. Of last month's total, £941,547 represented spinning and twisting machinery and £243,797 weaving machinery. The aggregate value of shipments of British textile machinery during the eleven completed months of the present year is £10,822,203, against £9,106,728 and £11,090,112 in the corresponding periods of 1926 and 1925. The British East Indies were the largest individual market during November, shipments thence being valued at £255,880, followed by Germany with £123,123, the Netherlands with £104,851, Russia with £88,634, South America with £67,721, Australia with £62,763, the United States with £56,197, France with £54,552, Japan with £33,099, and China with £18,686, "other European countries" accounting for no less than £313,873.

A Remedy for "Hot" Pits.

What was described as a solution of the hot temperature problem in deep coal mines was discussed by Mr. A. Miller, in a paper read before the Manchester Geological and Mining Society. The principal feature of the system, which is in use at the mines of Andrew Knowles and Sons, Ltd., Pendlebury, Manchester, is that the force of gravitation is utilised for ventilating the whole of the workings, so that artificial power is entirely dispensed with, the dangers and difficulties of descentional ventilation completely obviated, and the amount of leakage reduced to the lowest possible point. Before this system was introduced fire-damp had been found at the highest point of the rise workings, and brattice cloths had to be fixed from the packs to within a very short distance from the coal face. Since its introduction, Mr. Miller pointed out, all brattice cloths had been removed and there had not been the slightest trace of fire-damp at the highest point of the rise workings in any of the three lower seams. The system of natural ventilation has the great advantage over the orthodox system of artificial ventilation that the deep-mine worker is never subjected to draughts, and is able to work with nothing on except the flimsiest clothing.

Port of Manchester Developments.

The port of Manchester authorities have spent about £3,000,000 on development work during the present year. The principal new works include wharfage construction and warehouse extensions, the construction of the oil dock at Stanlow, transit sheds at No. 9 Dock, railway extensions, and extensive developments at Ellesmere Port, which are nearing completion, as well as heavy capital expenditure on additional plant and equipment. The Ship Canal has been deepened from 28ft. to 30ft. from Eastham Docks to the river Gowy, and the approach at Eastham has also been deepened. Among minor developments during the year has been the reconditioning of the swing aqueduct at Barton.

Artificial Silk Machinery.

It has been reported during the last few days that a provisional arrangement has been made for Dobson and Barlow, Ltd., Bolton, textile machinery manufacturers, to equip a large new artificial silk factory on the Clyde, the value of the plant required being placed at £158,000.

Personal.

Mr. L. Romero has been appointed chief electrical engineer to the Salford Corporation, in succession to Mr. S. J. Watson, who is now chief adviser to the London and Home Counties Joint Electricity Authority. Mr. Romero, who, since 1911, has been mains superintendent at Salford,

has conditionally occupied the position of chief electrical engineer since Mr. Watson left for London last July.

Non-ferrous Metals.

From the point of view of prices there has been little in the way of important changes since last report, though the general tendency of the non-ferrous metals market can hardly be described as strong at the moment. Tin and spelter have lost ground to some extent, with lead a trifle higher than it was a week ago. In the case of tin, buying interest continues only on a moderate scale, so far as home users are concerned, although it is said that consumers on the Continent are still fairly active buyers. In view of the fact that stocks of the metal in this country, according to the latest official returns, tend to increase it is rather a matter for surprise that market values have not given way more than they have. The turnover in copper during the past week has been below the average, but prices of refined metal and of manufactured copper have held fairly firm. So far as lead is concerned, a quiet business has been put through on the home markets, and, if anything, values are a shilling or two higher on balance. Spelter, however, has been slow, and quotations in this section of the market are fractionally lower than a week ago.

Iron.

With the demand for pig iron on the Lancashire market still very subdued, and few inquiries coming forward for delivery in the early part of next year, interest has been at a very low ebb. The poor buying of recent weeks has had an effect on the stocks of foundry iron at blast-furnaces in the Midlands, and for the first time for several months an increase in these is now being reported. To a large extent, of course, this may be said to be seasonal, for as well as deferring new contract commitments until after the holidays, consumers at this time of the year normally restrict specifications against existing contracts. At the same time, this position does not make for strong markets, and although values as a whole have not changed appreciably since last week, the tendency at the moment seems to favour buyers. Derbyshire brands, for delivery Manchester or equal distance, are quoted at from 73s. to 73s. 6d. per ton, the lower figure being the more general, whilst Staffordshire makes are on offer at about 72s. 6d., Cleveland at 78s. 2d., Scottish from 88s. upwards, and West Coast hematite at from 84s. 6d. to 85s. Lancashire bar iron remains steady at £10 per ton for Crown quality material and £9 10s. for seconds, but business in this section of the market is dull.

Steel.

Local constructional engineers continue fairly busy and the prospects in this important section of the steel-consuming industries are regarded as favourable. In common with most other users, however, buying operations proceed on very cautious lines, and during the past week, probably under the influence of the approaching holiday break, business has been very moderate. The demand for boiler plates has been quiet and patchy, with quotations easy at from £10 2s. 6d. to £10 5s. per ton, according to quantity. Steel bars, also, continue to display easiness, current values ranging from £7 10s. to £8 10s. per ton, according to size. Ship plates are held at the minimum price of £8 7s. 6d. per ton; as are also joists and sections at £7 12s. 6d. The market for continental iron and steel products has been featureless, and current transactions have been largely a question of small-sized parcels of finished materials. Steel bars are inclined to be firmer at from £5 18s. 6d. to £6 per ton, for cash against documents, and including delivery to users' works in this area, but Siemens plates are about unchanged at £7 10s. to £7 12s. 6d., Thomas plates at £7 2s. 6d., wire rods at £6 8s. 6d., sections at £5 12s. 6d., billets at £4 18s. 6d., and sheet bars at about £5. Belgian No. 3 bar iron has moved up a little, the present range being from £5 16s. to £5 17s. 6d. per ton.

BARROW-IN-FURNESS.

Hematite.

The hematite pig iron market in this district has taken on even a quieter tone, and the stocks in the district still amount to a considerable tonnage. Probably the Christmas holidays have affected the market, but the amount of business activity is small. What may come in the New Year it is very difficult to say. Judging from present signs there does not seem to be much possibility of an early revival in the pig iron trade. Customers are keeping their orders down just to meet immediate requirements. Booking for forward delivery is noticeable by its absence. There are eleven furnaces in blast in the district, and there is no doubt that this number would be reduced but for the fact that the steelworks, especially at Barrow, take up a considerable quantity. The iron trade is only moderate, inasmuch as the deliveries outside the district are by no means substantial. Foreign ore is being brought in in restricted tonnage. The steel trade is fairly well employed at Barrow, and the rail, merchants', Siemens and hoop departments are all employed. There will be a short break for the Christmas holidays, but this will not be of long duration.

Shipbuilding and Engineering.

It is a sign of the times when the Christmas holidays at Vickers' Naval Construction Works are kept down to a few days, as is the case this year. Contracts which are held are considerable, and no time must be lost on any of them. The Orient liner, which was only launched in September, has to be on her station in April, and other contracts, including the two Admiralty boats and many contracts in the gunmetal department, cannot be delayed. The prospects for Vickers' works at Barrow for 1928 can be considered fairly good, and there is just a possibility that the position may even be improved within the next few months.

SHEFFIELD.

(From our own Correspondent.)

State of the Steel Trade.

THE year is drawing to a close with unsatisfactory reports from many branches of the steel trade, but at the same time with confidence in the future. The holiday arrangements are on a larger scale than usual. In the majority of cases works are shutting down from to-day until Tuesday next, and will have a similar break for the New Year. Some will be closed for the whole of next week, while several of the largest establishments will be closed for a fortnight. The great steel works at Templeborough and the Ickles come within the last-named category. During the past week there has been a falling off in orders for billets, bar iron, railway material, heavy forgings, and all classes of semi-manufactured steel. In some cases, however, there has been increased activity in order that work in hand might be completed before the stoppage. The departments making special steel for the moving parts of motor cars, and stainless steel for many engineering purposes, continue to be among the brightest spots in local industry. A good deal of quietude is reported from the finished trades which deal with farm tools and implement parts, drawn tubes, and crucible steel. In North Lincolnshire, out of a total of 22 blast-furnaces, 12 are idle. The iron and steel markets are very dull, and prices, already low, are capable of shading for spot orders. Although there is a growing belief that higher prices will rule in the early part of the New Year, consumers show little disposition to order forward.

A Stainless Tramcar.

The extent to which the use of stainless steel has been developed for fittings of all kinds is shown by the fact that a "stainless tramcar" is now running in Sheffield. It has just been put into service on the Mill-houses route. The whole of the metal parts of the car, numbering a hundred, are made of "Firth–Staybrite silver steel." Another item of vehicular interest is that Sheffield is now running six-wheeler omnibuses, accommodating sixty-six passengers, the chassis frames of which are made of heat-treated high-tensile steel manufactured by Sanderson Bros. and Newbould, Ltd., Sheffield. The vehicles have been constructed by Karrier Motors, Huddersfield.

Notable Casting Feat.

Cammell, Laird and Co., Ltd., have accomplished an intricate and difficult piece of work at their Grimesthorpe Works, Sheffield. It consisted of the casting of a steel rotor hub for a large hydro-electric generating set for the Far East. It was cast in two parts. The diameter of the hub is 16ft. 7in., and the total weight about 20 tons.

The Lighter Trades.

Activity has been well maintained in the cutlery and plate trades owing to the special demands of the Christmas season. A considerable quantity of goods was despatched during the week, and a good number of fresh orders came in. These related, however, in the main to very cheap classes of goods, the trade in which has been assisted by the exceptionally cheap supplies of celluloid that have been available. That side of the trade which produces domestic work is doing well, and there is, for instance, an increasing demand for spoons and forks which will not tarnish. The exports of cutlery in November were valued at £124,401, which was the largest monthly total for several years. As compared with October, there were increases in knives, scissors, and ordinary razors. Most of the overseas markets took larger quantities. Without safety razors and safety blades, however, the aggregate would have shown a decrease. The value of the safety razors exported was £13,767, and of safety blades £21,382. A considerable number of blades was sent to the United States. The imports of cutlery for the month amounted to £30,000, or about the same as in October, but for the eleven months they show an increase of nearly £100,000 on last year. The figures regarding the export of all classes of tools make cheering reading. There was an increase all round, more particularly in the file, saw and edge tool section. It is probable that the total for the year will be almost, if not quite, equal to those of recent years, although there has been so little done with Russia, and the sale of plantation tools to overseas has been very much down.

A New Peace Council.

A noteworthy step towards the attainment of peace in industry, by establishing a closer relationship between employers and employed, has been taken on the initiative of the Lord Mayor of Sheffield (Alderman M. Humberstone), who is a trade union leader. He called together representatives of both sides, and the result has been the formation of the Sheffield and District Engineering and Steel Trades Council. It is not intended that the new organisation shall interfere in questions of wages or working conditions. Its object is to bring about closer co-operation and a fuller understanding, in the hope of promoting a better feeling and preventing disputes. It has been cordially welcomed by representatives of employers and of trades unions alike. The Lord Mayor of Sheffield intends to try to establish a second body of the same kind in connection with the lighter trades of the city.

Low Temperature Carbonisation.

At the annual meeting of the Leeds Fireclay Company, Ltd., the chairman (Mr. Charles F. Spencer) referred to the company's acquisition of the exclusive British rights of the Plasmon process of low temperature carbonisation of coal. He said that the difficulty with such processes had always been to show a commercial profit, but, early in 1926, the attention of the directors was drawn to the very successful results obtained by a German firm. It was a continuous and automatic process which produced smokeless fuel in large lumps from coal slacks or fines. The tar or crude oil produced was of remarkable purity and free from coal dust in suspension; it was a freely-flowing brown liquid which could be used for fuel oil, boiler firing, or Diesel engines. Labour and operating costs appeared to have been reduced to a minimum. He announced that the company was installing a small plant capable of dealing with 2½ tons of coal, with a view to testing the suitability of the different kinds of coal for the process, and they hoped this small plant would be completed in January.

New Railway in Notts.

The only length of new railway for which Parliamentary powers will be sought next session is one which the London, Midland and Scottish Railway Company proposes to construct in Nottinghamshire. This is a short line of about one and a-half miles, consisting of a curve at Farnsfield to connect the company's Mansfield and Southwell Railway with the Mid-Nottinghamshire Joint Railways authorised by Parliament in 1926.

Electricity Extensions.

The Electricity Committee of Hull Corporation has accepted a tender for works extensions, amounting to £6166, from Messrs. A. E. Jones, Ltd., Hull. The Committee also had before it a scheme of assisted wiring, submitted by the engineer, making the period of repayment ten years as specified by the Electricity Commissioners. The scheme would not include any house or shop built after June, 1928. He informed the Committee that if the scheme was adopted it would be necessary to apply to the Commissioners for sanction to borrow £25,000. Discussion on the proposal was postponed. At Louth, the Town Council has decided to accept the terms offered by Grimsby Corporation to supply the town with electricity. The estimated cost of the scheme is £26,806, and a preliminary loan of £9000 is to be raised. The deficit is expected to be £1000 for the first year, £120 for the second, and £225 for the third, while from the fourth year onward a profit is expected, rising to £1500 in the tenth year.

New Waterworks.

Easingwold Rural Council has adopted a scheme for supplying the parishes of Coxwold, Thornton Hill, Oulston, Easingwold, and Crayke with water from Crockersdale Springs, near Oldstead. Messrs. Fairbank and Sons, of York, are the engineers. The tender of Messrs. Hall and Busfield, of Leeds, to carry out the work for the sum of £11,193 18s. 2d., has been accepted.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Iron Trade.

THE usual seasonal quietness is now being experienced in the Cleveland pig iron trade, but a steady expansion of business is expected in the New Year. Home business promises to be on a much larger scale, and there seems to be a possibility of some improvement in transactions with pig iron consumers in Scotland, who for some time past have been making extensive use of the comparatively very cheap continental iron. The outlook as regards the export trade is encouraging. Until very recently continental producers, through subsidies, low rates of wages, longer working hours and lighter taxation, were able to dump iron in the Cleveland district at lower prices than Cleveland ironmasters could themselves produce it. That is no longer the case. Continental prices have stiffened to the extent that it is no longer cheaper for Cleveland consumers to import rather than to buy in their own district, and local requirements have shown a marked expansion during the past two or three weeks. Moreover, inquiries are coming forward from the Continent, and several sales have been arranged. For all home and foreign business, except with Scotland, makers adhere to their fixed quotations. It is understood that customers across the Tweed are able to make purchases at 1s. to 1s. 3d. below the following recognised rates for all other business:—No 1 quality, 67s. 7d.; No. 3 G.M.B., 65s.; No. 4 foundry, 64s.; and No. 4 forge, 63s.

Hematite Pig Iron.

Recent sales of East Coast hematite have been on a scale sufficient not only to absorb the restricted make, but to necessitate some withdrawal from stocks, and confidence in steady growth of demand is emphasised by the action of Messrs. Pease and Partners in blowing in two furnaces that have been standing idle at their Tees Ironworks, though the firm may put a furnace out of operation at its Normanby Ironworks. Prices are still somewhat irregular, but tend steadier. Ordinary brands of hematite are in a little demand nowadays, customers as a rule stipulating for iron to special analysis. Makers quote on the basis of 71s. for mixed numbers, but while they complain that such terms are unremunerative, they are prepared to accept rather less.

Ironmaking Materials.

As regards foreign ore, the position is unchanged. Consumers are buying only odd cargoes, but the paucity of business does not weaken the hands of sellers, who adhere to quotations on the basis of best Rubio ore at 21s. per ton c.i.f. Tees. Users of Durham blast-furnace coke are slow to negotiate at all extensively for supplies of that commodity, though makers protest that ruling rates are well below cost and that further price concessions will not be made. Good average qualities are in the neighbourhood of 17s. 6d. per ton delivered at the works.

Manufactured Iron and Steel.

The various branches of the manufactured iron and steel present no new features of moment. Semi-finished steel is only moderately taken up, as also is finished

steel, but producers are taking a rather firmer stand in view of the possibility of a lock-out in Germany. Quotations are unaltered.

Shipbuilding.

Sir W. G. Armstrong, Whitworth and Co., Ltd., booked an order this week from the Anglo-Saxon Petroleum Company, Ltd., for a steam-driven oil tank vessel, similar to the one at present under construction in their yard for the same owners. The engines will also be built on the Tyne. The shipbuilding industry on the river Wear has had a much better year than last year, the 1927 output of thirty-eight vessels of 163,194 aggregate gross tonnage being the best since 1924. Last year the output was the lowest on record, being only eight ships and 36,979 tons gross. With the exception of 1924, this year's figures are the best since 1920, which were practically a record, being sixty-seven vessels and 333,335 tons. Thus this year's output is a little less than half that of a very good year on the river.

The Coal Trade.

Everybody in the Northern coal trade is now taking stock of things and wondering what the New Year will bring forth. There are so many factors to take into consideration, however, that it is impossible even to guess at what conditions may be. Collieries are selling at cost or below, and they will not have next year any compensating higher-priced contracts as they had this year. Moreover, there is little prospect of better prices being obtained abroad, owing to the abundance of coal everywhere. Miners' wages may undego some revision through the county agreements directly, and until that is ascertained it is useless to speculate on the future position. In the meantime a comfortable position is assured until the end of the year in almost all sections of the market. Collieries are not quoting forward to any great extent, but for prompt trade they are well booked. Speculative business has been active of late and there is a good deal of selling and offering going on. Fuel requirements are well covered for this month and into the first week in January, but contractors are offering supplies for the latter part of January at prices under those now quoted. A feature in the steam coal section is the large number of inquiries from the Scandinavian countries for the first quarter of next year, but prices indicated are much below local ideas. Best Northumberland steams are quoted at 14s., and seconds at 12s. 3d. to 12s. 6d. Coking coals are in sustained request, and some sellers have no more to offer to the end of the year. The 13s. 9d. mark for best qualities is likely to develop into a full 14s. market. The secondary grades, however, are freely offered at 13s. 6d. to 13s. 9d. Steam smalls are favourably situated at late figures. Best qualities of Durham gas coke are in brisk request at 15s. 6d. to 16s., but seconds could do with more trade. The coke market is more active for patent oven cokes, and bookings for early delivery and over the next three months have been substantial, and values are firm, good ordinary being 17s. to 18s. 6d., special makes 23s. to 25s., and beehive 30s. Gas coke is in quiet demand, but steady, and early supplies are sparingly offered at 22s. 6d. to 24s.

Coal Miners' Wages.

The unfortunate state of the export section of the Northumberland coal trade, by far the principal source of revenue of the coalowners, and therefore the main spring from which wages flow, has reached such a level that drastic measures must be applied. Officially, no effort so far has been made to meet the competition from continental coalfields by a readjustment of wages in Northumberland, but it is not improbable that some action on these lines may have to be taken. At all events, a meeting was held this week between the Northumberland coalowners and the representatives of the Mine Workers' Federation to discuss the serious condition of the industry and to consider whether means could be devised to improve the situation. The meeting was adjourned after a frank and free discussion on the whole situation and an exchange of views. In the meantime both sides will give consideration to what was said.

SCOTLAND.

(From our own Correspondent.)

Slowing Down.

WITH the approach of the New Year holidays and in view of the depression in the steel, iron and coal trades, the dullness in the various markets has become accentuated, which is in marked contrast to the rush for supplies usually experienced in normal times at this season of the year.

Steel.

The steel market continues without any fresh feature. New business is very scarce, and makers have great difficulty in securing specifications of plates and sections sufficient to keep mills even partially employed. Some works have fairly steady shipbuilding demands, but the requirements of heavy material for other purposes appears limited. Continental competition is still in evidence.

Steel Sheets.

Producers of steel sheets are only moderately busy. Heavy gauges are more or less neglected, while the demand for the lighter varieties is much quieter. Galvanised corrugated sheets, 24 b.g., for export are quoted about £13 5s. per ton.

Ferro-manganese Dearer.

For delivery at steel works in this district ferro-manganese has been advanced in price by 10s. per ton, thus making the current quotation £13 10s. per ton, basis 78 per cent.

Iron.

The demand for bar iron is still exceedingly poor, and though orders for re-rolled steel bars offer some compensation, the works generally are in an unsatisfactory position, and the market depressing. Bar iron for home delivery remains at £10 5s., and re-rolled steel bars at £7 15s. per ton, while export business can be done at 5s. and 15s. per ton less respectively.

Pig Iron.

There has been no change in the pig iron market. Home requirements are exceedingly modest and export business extremely limited. Prices are inclined to further weakness.

Scrap.

The demand for scrap is uneven. Heavy steel scrap is quoted round about 57s. 6d. and basic about 5s. per ton cheaper.

Exports and Imports.

Nearly 13,000 tons of iron ore were discharged at Clyde docks last week, and approximately 1730 tons of iron, the latter from continental ports. Shipments of iron products amounted to 2400 tons, while considerable quantities of machinery and structural material were dispatched overseas.

Coal.

Owing to restricted outputs and further covering of sales against December shipments, supplies of fuel for export have become scarce, and prices have firmed up in consequence. Only odd lots necessary to complete cargoes are available in most descriptions of large coal, and nuts, with the possible exception of trebles, are similarly situated. The withdrawal of the French restrictions on imports has gratified shippers, and hopes are entertained of an expansion of business in this direction in the New Year. In the home market industrial and household demands are not yet up to normal for the season of the year.

New Colliery.

It has been announced that despite the depression in the coal trade, the Coltness Iron Company, Ltd., Newmains, intends sinking two shafts and putting down a new colliery in Overtown, which would provide work in that district for many years to come.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

RETURNS to hand show that exports of coal from this district last week were slightly less than 358,000 tons, as compared with rather more than 415,000 tons in the preceding week. This total is disappointing, but it is possible that the figure is somewhat misleading. The position is that exporters are allowed a few days' grace in which to make their returns, and for this reason the figure may be far below the correct total. It will be surprising if this is not the case, as from the tonnage to hand and the increased activity prevailing, it was generally thought that there would have been an improvement and not a reduction. Certainly the supply of tonnage fell off towards the end of the week, as there were forty-one idle tipping appliances at the various docks on Saturday, and, unfortunately, the very bad weather over the week-end prevented many steamers making port as expected. Furthermore, it is not unlikely that shipments during the current week will fall below what would have been expected in normal conditions, as owing to the severe weather, quite a number of tipping appliances were frozen and unworkable in the early part of this week, and comparatively little loading was carried out. It is very many years since the conditions in this respect were so bad, but when work can be carried out properly there should be a good spell of activity, as there is no doubt that many of the leading undertakings are much better stemmed for the next fortnight. Chartering operations reveal that the outlook is better, as the amount of tonnage taken up for the week ended the 15th inst. reached over 300,000 tons, which is above the average. Chartering has of late been very active for South America, the quantity of tonnage fixed to load coals for Rio de Janeiro being round about 100,000 tons. Fresh inquiry on the market is far from being brisk, but the Spanish Marine has purchased 12,000 tons of superior Welsh coals for early delivery, and it is reported that the French Marine has bought 13,000 tons of large coal for delivery over the next month through a French firm. It is also stated that the Argentine Railways have entered into a contract for 40,000 tons of best Admiralty large coals for delivery over the first six months of next year, while confirmation has come to hand regarding the purchase of 100,000 metric tons of large coals for delivery at Alexandria over the first four months of next year for the Egyptian State Railways, the firm to secure the contract being Watts, Watts and Co., Ltd., whose price was 27s. 2d. per ton, c.i.f. Alexandria.

French Coal Embargo Removal.

The announcement was made last week by the British National Committee of the International Chamber of Commerce that the chairman of that body had been informed that the Decree of May 25th last, imposing restrictions on the importation of coal into France, will be withdrawn at once. No news has come to hand as to the exact date upon which the barrier is to be removed, but expectations are held that the New Year will be started with all restrictions abolished; at least, that is the hope entertained. The announcement occasioned very little surprise in this district, but exporters do not look for an immediate expansion in the demand for coals for France. It may take some time before trade improves to any appreciable extent. It is interesting to note that statistics show that for the first five months of this year the average monthly quantity of coals which France took from this country was round about 790,000 metric tons, whereas the monthly average for May to October, when the licensing system operated, was only about 712,000 metric tons. In the case of Germany, her exports to France for the first five months of this year averaged 726,000 metric tons, whereas since then they have only averaged 378,000 metric tons monthly.

Centralised Italian Coal Buying.

Reference was made in my last letter to the suggestion which has been put forward in Italy that coal supplies for that country should be purchased through a central agency, the idea of the advocates of the scheme being that the countries which export the coals to Italy should reciprocate by taking the equivalent value in Italian products. From what can be gathered, it is scarcely likely that the proposal of the Italian Government will materialise without strong opposition, not only from exporting countries, but from the importing interests in Italy. It is stated that already special meetings of coal-importing firms in that country have been held, and that it was decided to address a telegram to the Government strongly protesting against the adoption of such a scheme on the ground that its effect would be to create a monopoly and interfere with the principle of freedom in the coal trade from which Italy has so greatly benefited in the past.

Rail Rates and Dock Dues.

The Cardiff Chamber of Commerce at a meeting on Monday decided to appoint a committee consisting of representatives of all interested sections to investigate the position of Cardiff and its general cargo trade, in order to see how it is adversely affected by the question of high railway rates and dock charges as compared with other centres. The object is, of course, to endeavour to secure lower charges from the railway company, and the committee will consider how best this can be achieved.

Dock Statistics.

For the month ended November 27th last the returns of trade for the six docks under the control of the Great Western Railway Company show a total of 2,829,982 tons, which compared with 2,617,651 tons for the preceding four weeks. Imports came to 392,824 tons, as against 424,636 tons, while exports amounted to 2,437,158 tons, as compared with 2,193,015 tons. For the forty-eight weeks ended November 27th last, the aggregate of imports and exports for the six ports of Cardiff, Swansea, Newport, Barry, Port Talbot and Penarth, was 34,297,064 tons, which compares with 17,754,669 tons for the same period of last year, and with 31,854,477 tons for the same period of 1925.

Current Business.

The daily demand for coals for prompt shipment continues to be quite featureless and no perceptible improvement can be noted, yet at the same time collieries are undoubtedly better off, and in some cases have quite good stems for the remainder of this year. In some quarters there appears to be a prospect even of a slight improvement in prices before very long. The tone of the market is certainly steadier, but much depends upon whether tonnage comes to hand as arranged. Nominally, coal and coke and patent fuel prices remain unaltered.

LAUNCHES AND TRIAL TRIPS.

SEFWI and WALA, steel lighters; built by Harland and Wolff, Ltd., to the order of Elder, Dempster and Co., Ltd.; dimensions, 65ft. by 16ft. 6in. by 6ft. 3in.; to carry 90 tons; launch November 28th.

CABO ESPICHEL, tug and salvage steamer; built by Harland and Wolff, Ltd., to the order of the Lisbon Harbour Board; dimensions, 135ft. by 27ft. by 13ft. 6in. Engines, triple-expansion, surface condensing; constructed by McKie and Baxter, Ltd.; launch, November 29th.

OIL TRADER, steel tank steamer; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of the British Oil Shipping Company, Ltd.; dimensions, 424ft. by 53ft. 5in. beam; 8600 tons deadweight. Engines, triple-expansion, pressure 200 lb.; constructed by the builders; trial trip, December 1st.

THEDEUS, steamship; built by the N.V. Int. Scheepsbouwmij "De Maas," of Slikkerveer, Holland, to the order of the Royal Packet Company, of Amsterdam; dimensions, 299ft. 10½in. by 45ft. 11in. by 17ft.; 1340 tons deadweight; displacement, 3340 tons. Engines, triple-expansion, 1700 I.H.P., built by Messrs. Fyenoord, of Rotterdam; launch, December 3rd.

VOCO, oil tanker; built by Lithgows, Ltd., to the order of the Vacuum Oil Company, Ltd.; dimensions, 460ft. 6in. by 62ft. 6in. by 36ft. 6in.; 12,770 tons deadweight. Engines, inverted direct-acting triple-expansion, pressure 220 lb.; constructed by David Rowan and Co., Ltd.; trial trip, December 6th.

ACOSTA, oil tank steamer; built by Palmers Shipbuilding and Iron Company, Ltd., to the order of the Venezuela Gulf Oil Company. Engines constructed by MacColl and Pollock; launch, December 7th.

INSTITUTE OF CHEMISTRY.—On Thursday evening of last week the Institute of Chemistry held a banquet in celebration of its Jubilee at the Hotel Great Central, Marylebone. Over five hundred members and guests attended. Following the dinner, the President, Professor Arthur Smitheils, read a message of greeting which had been received from H.R.H. the Prince of Wales, the Patron of the Institute. Subsequently addresses of congratulation to the Institute on attaining its fiftieth year were submitted by delegates from the Royal Society, the Chemical Society, the Society of Chemical Industry, the British Association, the Society of Public Analysists, and the Oil and Colour Association. Thereafter Sir Alfred Mond proposed the toast of "The Institute of Chemistry of Great Britain and Ireland," which was replied to by the President. "The Founders and Past-Presidents of the Institute," was proposed by Mr. C. A. Hill, and was replied to by Professor J. Millar Thomson, who was President of the Institute in 1901–1903. "The Guests," proposed by Mr. A. C. Chapman, was replied to by Sir Ernest Rutherford, President of the Royal Society and by Sir Atul Chatterjee, High Commissioner for India.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
Native	18/6 to 21/-
(1) Spanish	18/6 to 21/-
(1) N. African	18/6 to 21/-
N.E. COAST—	
Native	18/- to 21/-
Foreign (c.i.f.)	21/-

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	3 16 0	—
No. 1 Foundry	3 15 0	—
No. 3 Foundry	3 10 0	—
N.E. COAST—		
Hematite Mixed Nos.	3 11 0	3 11 0
No. 1	3 11 6	3 11 6
Cleveland—		
No. 1	3 7 6	3 7 6
Silicious Iron	3 7 6	3 7 6
No. 3 G.M.B.	3 5 0	3 5 0
No. 4 Foundry	3 4 0	3 4 0
No. 4 Forge	3 3 6	3 3 6
Mottled	3 3 0	3 3 0
White	3 3 0	3 3 0
MIDLANDS—		
(3) Staffs.—		
All-mine (Cold Blast)	—	—
North Staffs. Forge	—	—
" " Foundry	3 6 0	—
(3) Northampton—		
Foundry No. 3	3 0 6 to 3 1 0	
Forge	2 14 0	—
(3) Derbyshire—		
No. 3 Foundry	3 5 0 to 3 6 0	
Forge	2 19 0	—
(3) Lincolnshire—		
No. 3 Foundry	3 4 0 to 3 5 0	
No. 4 Forge	3 2 6	—
Basic	3 2 6	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 4 0 (a) / 4 7 0 (b) / 4 10 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export £ s. d.
SCOTLAND—		
Crown Bars	10 5 0	10 0 0
Best	—	—
N.E. COAST—		
Iron Rivets	11 5 0	—
Common Bars	10 5 0	—
Best Bars	10 15 0	—
LANCS.—		
Crown Bars	10 0 0	—
Second Quality Bars	9 10 0	—
Hoops	12 10 0	—
S. YORKS.—		
Crown Bars	10 10 0	—
Best Bars	11 15 0	—
Hoops	12 10 0	—
MIDLANDS—		
Crown Bars	9 10 0 to 10 0 0	
Marked Bars (Staffs.)	13 0 0	—
Nut and Bolt Bars	9 0 0 to 9 5 0	
Gas Tube Strip	11 10 0	—

STEEL. (d)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	10 10 0	10 10 0
Ship Plates, ½in. and up	8 2 6	7 12 6
Sections	7 12 6	7 2 6
Steel Sheets, ¼in.	8 17 6	8 15 0
Sheets (Gal. Cor. 24 B.G.)	13 12 6	£13 5 0

STEEL (continued).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	8 2 6	—
Angles	7 12 6	—
Boiler Plates	12 10 0	—
Joists	7 12 6	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	8 2 6	—
Soft Billets	7 5 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	8 5 0	—
Light Rails	8 10 0 to 8 15 0	
Billets	7 10 0 to 10 0 0	
MANCHESTER—		
Bars (Round)	8 10 0	—
" (Small Round)	7 10 0	—
Hoops (Baling)	10 5 0	10 0 0
" (Soft Steel)	9 0 0	8 15 0
Plates	8 7 6	—
" (Lancs. Boiler)	10 5 0	—
SHEFFIELD—		
Siemens Acid Billets	10 0 0	—
Hard Basic	7 12 6 to 8 2 6	
Intermediate Basic	7 10 0	—
Soft Basic	6 10 0	—
Hoops	10 0 0 to 10 10 0	
Soft Wire Rods	9 0 0	—
MIDLANDS—		
Small Rolled Bars	7 7 6 to 8 0 0	
Billets and Sheet Bars	6 0 0 to 6 5 0	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	13 0 0 to 13 10 0	
Angles	7 12 6	—
Joists	7 12 6	—
Tees	8 12 6	—
Bridge and Tank Plates	8 7 6	—
Boiler Plates	11 0 0 to 11 10 0	

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	18/- to 18/3
Block Tin (cash)	264 5 0
" (three months)	261 15 0
Copper (cash)	59 11 3
" (three months)	59 15 3
Spanish Lead (cash)	21 16 3
" (three months)	22 2 6
Spelter (cash)	26 6 3
" (three months)	26 0 0
MANCHESTER—	
Copper, Best Selected Ingots	66 7 6
" Electrolytic	67 0 0
" Strong Sheets	90 0 0
" Tubes (Basis Price), lb.	0 1 0¾
Brass Tubes (Basis Price), lb.	0 0 11¾
" Condenser, lb.	0 1 1¾
Lead, English	23 12 6
" Foreign	22 7 6
Spelter	26 10 0
Aluminium (per ton)	£107

FERRO ALLOYS.

	Per Ton	Per Unit.
Tungsten Metal Powder	1/8 per lb.	
Ferro Tungsten	1/4 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/6
" " 6 p.c. to 8 p.c. "	£22 17 6	7/3
" " 8 p.c. to 10 p.c. "	£22 10 0	6/6
" " Specially Refined		
" " Max. 2 p.c. carbon	£36 0 0	11/6
" " " 1 p.c. carbon	£41 10 0	15/-
" " " 0·70 p.c. carbon	£53 0 0	17/6
" " " carbon free	1/4 per lb.	
Metallic Chromium	3/- per lb.	
Ferro Manganese (per ton)	£13 0 0 for home £12 for export	
" Silicon, 45 p.c. to 50 p.c.	£12 15 0 scale 5/- per unit	
" " 75 p.c.	£20 5 0 scale 6/- per unit	
" Vanadium	14/3 per lb.	
" Molybdenum	5/- per lb.	
" Titanium (carbon free)	0/11½ per lb.	
Nickel (per ton)	£175	
Ferro-Cobalt	9/3 per lb.	

FUELS.

SCOTLAND.
(Prices not stable.)

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	13/9
" " Ell	14/6
" " Splint	17/- to 18/6
" " Trebles	14/6
" " Doubles	14/- to 14/3
" " Singles	12/- to 12/6
AYRSHIRE—	
(f.o.b. Ports)—Steam	13/3
" " Jewel	15/6
" " Trebles	14/3
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	12/6 to 13/-
Screened Navigation	18/-
Trebles	14/9 to 16/-
Doubles	14/3
Singles	12/- to 12/6
LOTHIANS—	
(f.o.b. Leith)—Best Steam	12/9
Secondary Steam	12/3
Trebles	14/6
Doubles	14/3
Singles	12/-

ENGLAND.

	Inland.
(8) N.W. COAST—	
Steams	24/- to 25/-
Household	40/- to 56/-
Coke	23/- to 24/-
NORTHUMBERLAND—	
Best Steams	13/6 to 14/-
Second Steams	12/9 to 13/-
Steam Smalls	9/- to 9/9
Unscreened	13/- to 13/6
Household	21/- to 27/-
DURHAM—	
Best Gas	15/9
Second	13/9 to 14/-
Household	21/- to 27/-
Foundry Coke	19/- to 26/-
SHEFFIELD—	Inland.
Best Hand-picked Branch	27/6 to 29/6 —
Derbyshire Best Bright House	20/6 to 21/6 —
Best House Coal	19/- to 20/6 —
Screened House Coal	16/- to 17/6 —
" " Nuts	15/- to 16/- —
Yorkshire Hards	14/6 to 15/6 —
Derbyshire Hards	14/- to 15/6 —
Rough Slacks	8/6 to 9/6 —
Nutty Slacks	6/- to 7/- —
Smalls	3/- to 4/6 —
Blast-furnace Coke (Inland)	11/- to 12/- at ovens —
Furnace and Foundry Coke (Export), f.o.b.	17/6 to 18/6

CARDIFF— (9) SOUTH WALES.

Steam Coals:	
Best Smokeless Large	19/- to 19/6
Second Smokeless Large	18/6 to 19/-
Best Dry Large	18/3 to 18/9
Ordinary Dry Large	17/6 to 18/-
Best Black Vein Large	17/6 to 18/-
Western Valley Large	17/- to 17/6
Best Eastern Valley Large	17/- to 17/3
Ordinary Eastern Valley Large	16/6 to 17/-
Best Steam Smalls	12/6 to 13/-
Ordinary Smalls	11/- to 12/6
Washed Nuts	18/- to 22/-
No. 3 Rhondda Large	19/6 to 20/-
" Smalls	14/9 to 15/3
No. 2 " Large	16/- to 16/6
" " Through	14/6 to 15/6
" " Smalls	11/6 to 12/6
Foundry Coke (export)	30/- to 37/6
Furnace Coke (export)	27/6 to 30/-
Patent Fuel	22/6 to 24/-
Pitwood (ex ship)	28/3 to 28/6
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	32/- to 34/-
Seconds	25/6 to 29/-
Red Vein	20/6 to 25/-
Machine-made Cobbles	35/- to 40/-
Nuts	38/6 to 42/6
Beans	22/6 to 27/6
Peas	17/- to 18/6
Breaker Duff	8/6 to 9/-
Rubbly Culm	8/- to 8/6
Steam Coals:	
Large	17/6 to 18/6
Seconds	16/- to 17/-
Smalls	9/9 to 10/9
Cargo Through	15/- to 16/-

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (a) Delivered Glasgow. (b) Delivered Sheffield. (c) Delivered Birmingham. (d) Rebate 7/6 joists and 5/- all other materials if home consumers confine purchases solely to British products.

French Engineering Notes.

(From our Correspondent in Paris.)

The Steel Situation.

As the year closes the situation of the steel industry is being reviewed with more concern than has yet been felt with regard to its future, and at a meeting of the Société d'Economie Nationale the subject was dealt with by eminent economists who did not conceal the fact that serious measures will have to be taken to organise the industry on a more rational basis. While the steel production in Europe, as a whole, is practically the same as it was in 1913, the production in France has increased considerably, in consequence of an active development of the metallurgical and engineering industries. There has consequently been over-production, and it has resulted in severe competition which has lowered prices, calculated on a gold basis, to something like 20 per cent. below the figures for 1913. At the same time, French producers have to pay more for their coke and coal, and they are burdened with much heavier fiscal charges. Until there is an improvement in the demand for steel the only thing possible is to crystallise the present situation by a series of agreements, the first of which was the creation of the Steel Union, but, so far, all efforts to come to an arrangement have failed, because there is always some firm or other or some group of producers who claim more than can be allotted to them or who object to an agreement on principle. At present several negotiations are in progress for centralising sales of steel products, and although at every meeting optimistic references are made to a probable early settlement, it is known that the negotiations are constantly threatened with failure, and there appears to be little hope of the unions being definitely constituted and coming into operation on January 1st as had been expected. If prices are not lower than they are now, it is because producers cannot accept less, and the occasional hardening of values is due solely to the prospect that has been held out from time to time of an understanding amongst producers for an advance in prices.

Coal.

As a consequence of the arrangement come to at Geneva for a suppression of prohibitions and restrictions, the French Government decided to withdraw the system of licences for the importation of coal, and that will be done as soon as the decree is published, probably on January 1st. This step has given satisfaction to consumers, who have long been complaining that, despite heavy stocks at the pits, prices of coal remain high, and it is hoped that a renewal of foreign competition will bring down prices sufficiently to aid an industrial recovery. French coalowners are naturally more concerned at the withdrawal of a protective measure which, nevertheless, does not appear to have rendered them the least service, since, according to their own showing, they are in a worse situation now than they were before the licence system was instituted. Industrial coal consumers, on the other hand, argue that the situation of coalowners is not so bad as they endeavour to make out, and that there is no excuse for the high prices that have been, it is said, artificially maintained while they enjoyed a practical monopoly of the home market. They further complain that the high prices of coal are partly responsible for the crisis through which the manufacturing industries are now passing. Meanwhile, the colliery companies have been urging upon the Minister of Public Works to do something for them, especially those in the Loire basin, who have suffered from the facilities offered for the transport of coal from the Nord and the Pas de Calais to the western seaboard, and the Minister states that he has obtained reductions in the railway transport of coal and coke from the Loire, while improved means of distribution are to be made in the northern coalfield. At the same time, the railway companies are invited to make known their requirements in coal during 1928, so that preference may be accorded, as far as possible, to French coal.

Coal Formation.

At the annual meeting of the Académie des Sciences the President, M. Charles Barrois, an eminent geologist, gave an account of the extraordinary formation of the coal deposits in the Nord, which, so far as is known, exist to a depth of 2000 m. There are 400 such layers, of which about 80 are sufficiently thick to be worked. The others are far too thin for practical mining. They are all horizontal and parallel, and are separated by strata of sand and mud. Thus the Nord coalfield has been covered alternately with vegetation and sand and mud no fewer than 400 times, and the earth's crust has undergone a gradual sinking until the lowest known carboniferous layer is found at a depth of nearly one and a-quarter miles. Such a formation, said M. Barrois, is unknown in any other part of the world.

Blast-furnace Gases.

The electrical purification of blast-furnace gases was the subject of an important conference at the Comité des Forges by M. Ziegel, who gave due acknowledgment to the early experiments carried out by Sir Oliver Lodge, and said that in 1917 an industrial application was made at the Poudreries d'Angoulême. The first application on a large scale was made at the Dilling Steelworks in the Saar, where from 10,000 to 15,000 cubic metres of blast-furnace gas an hour are purified by electricity, with the addition of an automatic cleaning system whereby the dust remaining in the gas is reduced to 8 to 15 milligrammes per cubic metre. A similar installation laid down at the Witkowitz Works in Czecko-Slovakia in July, 1926, has given such excellent results that it is being enlarged to deal with 240,000 cubic metres of blast-furnace gas an hour. A plant is under construction at the Homécourt Works of the Forges et Aciéries de la Marine and another at the Mannesmann Works at Duisburg for dealing with 270,000 cubic metres of gas per hour. M. Ziegel stated that while a plant for the electrical purification of blast-furnace gases cost a little more than that for the wet process it was much less than the cost of the dry filtering system, and the working costs were considerably lower.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

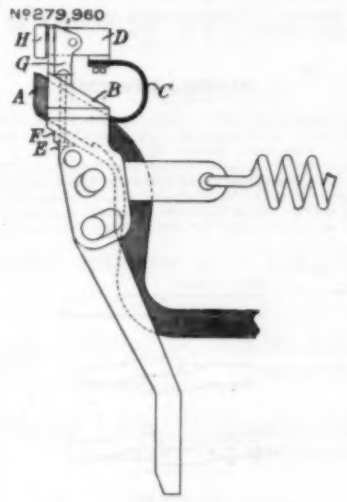
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

SWITCHGEAR.

279,960. August 13th, 1926.—IMPROVEMENTS RELATING TO ELECTRIC SWITCHES OR CIRCUIT INTERRUPTERS, Gustaf Adolf Juhlin, of Redscar, Moss-lane, Timperley, Chester, and Metropolitan-Vickers Electrical Company, Ltd., of 4, Central Buildings, Westminster.

A switch or circuit interrupter constructed in accordance with this invention consists of a main contact A in the form of a laminated copper conductor. The laminations may be composed

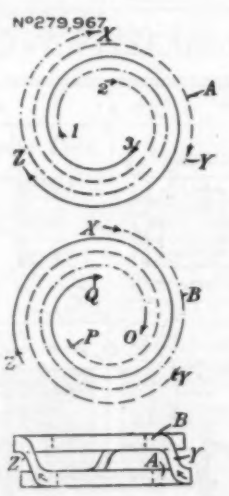


of braided material held within the clamp B. The extreme lower end of the laminated conductor is connected to some fixed part of the switchgear. A part of this conductor is turned upwards, as indicated at C, and is secured to the underside of the auxiliary contact carrying member D. The floating lever E is constructed at its upper end in the form of a box-like clamp, and is provided with a pair of upwardly extending ears G, with the pivoted member D which carries the arcing contact H.—*November 10th*, 1927.

TRANSFORMERS AND CONVERTERS.

279,967. August 18th, 1926.—IMPROVEMENTS IN AND RELATING TO WINDINGS FOR TRANSFORMERS, *The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2.*

This specification describes an electric transformer comprising a number of disc coils connected in series and slightly spaced from one another axially, each coil comprising a number of parallel-connected, radially-arranged conductors, the crossings of which from one coil to another, or from an end coil to the main line, are distributed uniformly over the periphery of the coils. In the case illustrated coils A and B are arranged one

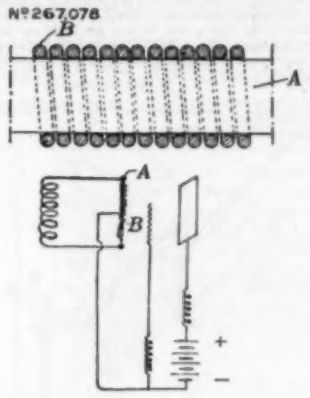


above the other, as shown in the lower drawing. Each coil consists of three conductors. The starting ends 1, 2, 3 in the inside of the coil A and are displaced 120 deg. apart. Each circuit is composed of 1½ turns per coil and the crossings X Y Z from the coil A to the coil B must therefore be distributed uniformly; likewise the ends O P Q of coil B. From these turns connections lead to the next coil. The individual conductors are thus uniformly interlinked with the flux and are equally loaded. The starting ends of the windings 1, 2 and 3 of the first coil and the ends of the last coil are connected to a collector ring to which the ingoing and outgoing lines are connected.—*November 10th*, 1927.

TELEGRAPHS AND TELEPHONES.

267,078. August 7th, 1926.—IMPROVEMENTS IN OR RELATING TO THERMIONIC VALVES, Société Française de Lampes à Incandescence "Luxor," of 8–10, rue des Frères Herbert, Levallois-Perret (Seine), France.

According to this invention the filament of a thermionic valve heated by alternating current is of relatively large cross-section, and owing to its composition it only emits electrons to a small extent. Around the filament there is a spiral or net B,

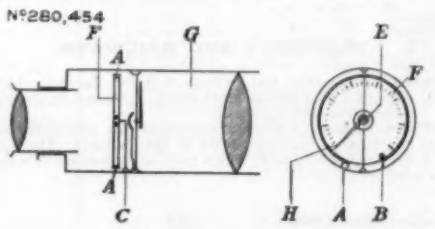


composed of fine wire or a thin band of ribbon, which, when heated, emits electrons readily. The electrical resistance of the core or filament A is, comparatively speaking, small, whilst that of the spiral B is great. The middle point of the cathode is connected to the negative pole of the high-tension battery and to earth, the object of this being to nullify the electrostatic action of the alternating current used for heating the filament. Preferably, the filament A should not emit electrons at all.—*November 7th*, 1927.

MEASURING AND TESTING INSTRUMENTS.

280,454. May 27th, 1927.—RADIATION PYROMETERS, A. Schwartz, Charlottenburger Ufer 53–54, Berlin-Charlottenburg, Germany.

A spiral bimetallic thermometer E with a pointer H is exposed to the concentrated beam of rays. The scale F, which serves for the observation of the temperature to be investigated, is rotatably supported upon a holder C. To the tube G a bimetallic spiral A

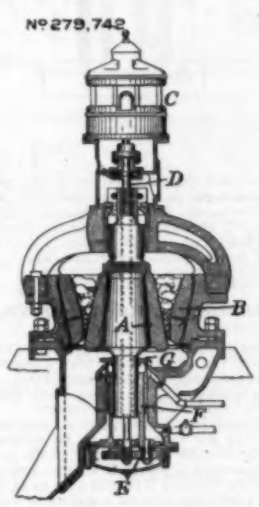


is secured by one end, while its free end B engages in a notch in the transparent scale F. Now, as soon as the pointer of the measuring spiral E alters its zero position under the influence of the room temperature, the compensation spiral A comes into action, since it is influenced in the same direction as the measuring spiral by the room temperature, and causes a displacement of the scale of such amplitude that the original zero position is restored.—*November 17th*, 1927.

CRUSHING AND GRINDING.

279,742. June 13th, 1927.—GYRATORY CRUSHERS, The Allis-Chalmers Manufacturing Company, 62nd and Shenners-avenues, Milwaukee, Wisconsin; and R. C. Newhouse, 1103, Ashland-avenue, Wilmette, Illinois.

This crusher is of the gyratory type, in which the crushing is effected between the conical faces A and B by giving the inner



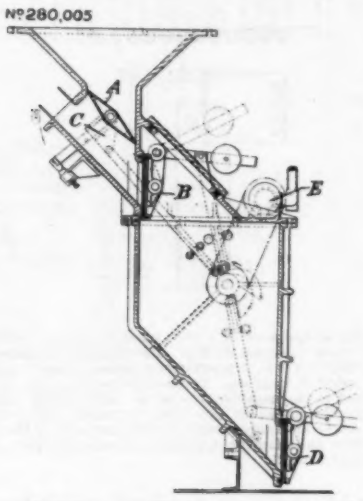
part A a gyratory movement. The object aimed at is to use a comparatively high-speed driving motor. This motor, C, is mounted above the machine in an accessible and safe position, and has its shaft D extended downward through an axial hole bored through the crushing member A. At the bottom there is

a set of planetary gearing E, which drives the excentric bushing F at a relatively low speed. This bushing, it will be seen, embraces the lower end of the crushing member A and gives it the requisite gyratory movement. The bushing and gears are protected from falling *débris* by the shield G.—*November 3rd*, 1927.

CRANES AND CONVEYORS.

280,005. October 4th, 1926.—GRAIN ELEVATORS, W. Littlejohn Philip, Westwood, Lansdown, Bath.

This apparatus is an air lock for the discharge end of a grain elevator working on the suction principle. The object of the invention is to ensure that there shall be no difficulty in closing the door admitting the grain to the air lock on account of its pressure on the door. To this end a butterfly valve A is arranged above the inlet door B to the air lock, and a recess C is provided

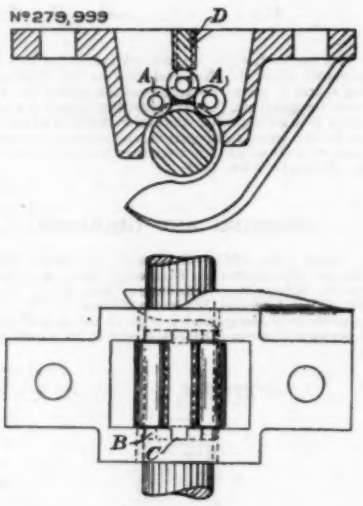


behind the door, into which any surplus grain may be pushed by the closing door. This recess, it is suggested, may be closed by a spring plunger. The butterfly valve, the inlet door and the outlet door D are all interconnected by means of cam gear and links, so that they will work in the proper sequence. There is also interconnected with the cam an air valve E, which alternately evacuates the air lock, and puts it in communication with the atmosphere to balance the pressure on both sides of the two doors when they are about to be opened.—*November 10th*, 1927.

TRAMWAYS AND RAILWAYS.

279,999. September 29th, 1926.—ROLLER BEARING AXLES, J. Guild, 12, Cavendish-place, and E. R. Harris, 32, Grainger-street, Newcastle-on-Tyne.

This roller bearing is specially intended for colliery tubs and may be either of the open type or have a keep. The rollers A A have reduced ends B, which may be cylindrical or conical,

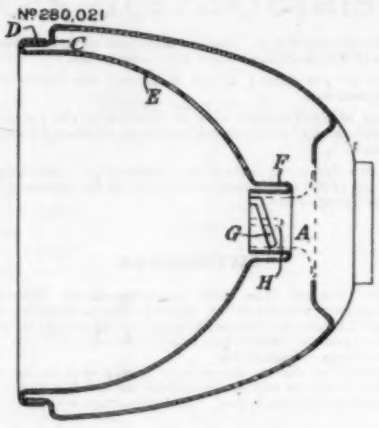


that engage in semi-circular grooves in the pedestal. These grooves are cast in the pedestal and need not, according to the inventors, be machined. The rollers are got in place by means of vertical grooves C, which are subsequently closed by the bridge piece D. The bridge piece is loose, but is held in place by the underframe of the tub.—*November 10th*, 1927.

MOTOR CARS AND ROAD TRAFFIC.

280,021. October 16th, 1926.—IMPROVEMENTS IN AND RELATING TO ELECTRIC HEADLAMPS AND LIKE ELECTRIC LAMPS, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2; and Cecil James Morton, of "Amubree," St. Paul's-road, Coventry.

An electric headlamp constructed in accordance with this invention enables the lamp bulb to be focussed. The bulb holder is rigidly secured to the casing at the point A, and the front end of the casing is provided with an annular rim C. The outer end D of the reflector E is bent over so as to make contact with the outer rim C, which forms a seating on which the reflector can rotate. The inner end F of the reflector is bent so as to form an annulus of U-shaped section, the inner ring of which is provided with diagonal slots G adapted to surround the outer end of the bulb holder A, which has corresponding axial slots H. The bulb is secured in position by revolving the reflector until the inlets to the diagonal and axial slots coincide and then pressing the projections on the lamp into the slots, the pressure being maintained until the reflector has been rotated sufficiently to trap the bulb. The focussing operation is then carried out by

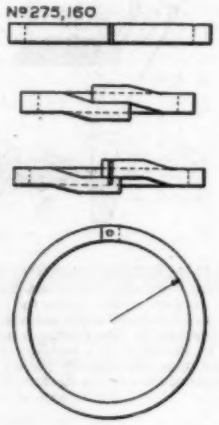


further rotation of the reflector in a direction which effects an axial displacement of the bulb.—*November 10th*, 1927.

MISCELLANEOUS.

275,160. March 1st, 1927.—METALLIC PACKINGS, Zaidan Hojin Rikagaku Kenkyujo, No. 31, Kamifujimae-cho, Komagome, Hongo-ku, Tokyo, Japan.

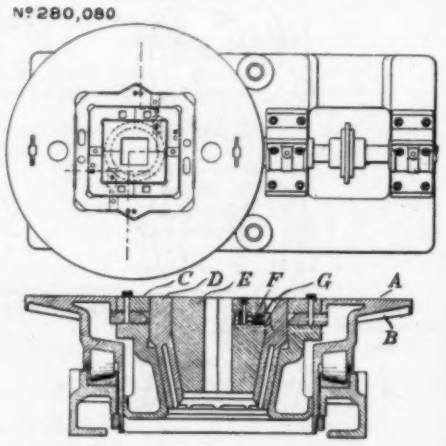
There is only one claim in this specification, and it reads as follows:—"A method of manufacturing a metallic packing ring for stuffing-boxes and like purposes which consists in first coiling a rod or wire to form a discontinuous ring, overlapping the ends to such an extent that the inner diameter is smaller than the



diameter of the rod to which it is to be applied, then opening out the ring by tangential force by means of a pin or a wedge, or by means of a magnetic chuck in the form of a series of electro-magnets arranged around the periphery of the ring blank, the inner diameter being still less than that of the finished ring, and then turning in a lathe the inner wall of the ring to such a diameter that it gives the necessary pressure upon the rod when in position." The drawing shows three stages in the process of manufacture.—*November 10th*, 1927.

280,080. February 21st, 1927.—WELL DRILLING MACHINES, E. E. Greve, 152, Grant-avenue, Bellevue, Allegheny, Pennsylvania.

This invention is concerned with the gear used to drive deep well boring "strings." The rotary movement of the string is imparted to the "table" A by means of bevel gearing meshing



with the teeth B. Within this table there is a series of bushings C D E to match up with the diameter of the string of tools. These bushings are squared to transmit the driving torque, as shown in the plan view, and are locked against vertical movement by spring plungers F, which may be forced back by inserting a tool through the hole G, when it is necessary to dismantle the bushings.—*November 10th*, 1927.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

THURSDAY, DECEMBER 29TH.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1.—Children's Christmas Lecture, "Engines—(I.) The Rules which all Engines Must Obey," by Professor E. N. da C. Andrade. 3 p.m.

FRIDAY, DECEMBER 30TH.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Lecturette, "The Burmese Lacquer Industry," by Mr. A. P. Morris. 7.30 p.m.

SATURDAY, DECEMBER 31ST.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Children's Christmas Lecture, "Engines (II). Learning About Steam," by Professor E. N. da C. Andrade. 3 p.m.

MONDAY, JANUARY 2ND.

INSTITUTION OF AUTOMOBILE ENGINEERS: WESTERN CENTRE.—Merchant Venturers' Technical College, Bristol. Paper, "The Electrical Characteristics of Spark Gap and Sparking Plugs," by Mr. E. A. Watson. 6.45 p.m.

TUESDAY, JANUARY 3RD.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "Some Notes on Reorganising a Works to Increase Production," by Mr. C. R. F. Engelbach. 7.45 p.m.

WEDNESDAY, JANUARY 4TH.

INSTITUTION OF CIVIL ENGINEERS: MANCHESTER AND DISTRICT ASSOCIATION.—Literary and Philosophical Society's Rooms, 36, George-street, Manchester. Paper, "Fatigue and Wear Testing of Materials," by Mr. J. S. Glen Primrose. 6.45 p.m.

FRIDAY, JANUARY 6TH.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's Gate, Westminster, London. S.W. 1. Thomas Lowe Gray Lecture, "The Marine Oil Engine," by Professor C. J. Hawkes. 6 p.m.

CONTRACTS.

HOLLINGS AND GUEST, Ltd., of Birmingham, have received an order for a large hydraulic plate flanging press for the Peking-Mukden Railway. The same firm also has in hand a repeat order for a large hydraulic baling installation for Ceylon, as well as a big pumping plant for the Birmingham Tame and Rea Drainage Board.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

GALLOWAYS, Ltd., Manchester, ask us to announce that they have acquired the goodwill, patterns and drawings of John Musgrave and Sons, Ltd., Bolton, together with the drawings of engines formerly built by John and Edward Wood, of Bolton.

MESSRS. CURCHIN AND WATSON ask us to announce that on and after December 24th their business will be transferred from 1, Seething-lane, to Bevis Marks House, Bevis Marks, London, E.C. 3. Telephone: Avenue 1430. Telegrams: Curchinwat, Ald., London.

WE are asked to announce that on January 1st next Mr. Frank Nasmith, F.T.I., will assume the position of executive manager for the United Kingdom of the Universal Winding Company, the head office of which is at Boston, Mass., and the works at Providence, R.I.

THE UNIVERSAL SYSTEM OF MACHINE MOULDING AND MACHINERY CO., Ltd., asks us to announce that it has moved its offices from 97, Queen Victoria-street, to 13-15, Wilson-street, London, E.C. 2. New telegraphic address:—Machimould, Finsquare, London. New telephone number: Clerkenwell 1276.

JOHN WILSON (LONDON), Ltd., asks us to announce that as its office building, 39, Lime-street, London, E.C. 3, is being demolished, it is removing to Bevis Marks House, Bevis Marks, E.C. 3, which will be its address after December 20th. Its telephone numbers will remain unaltered—Avenue 7470 and 7471—and its telegraphic address will be "Piping, Ald. London."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—The following programme of Friday evening discourses in the before Easter session of the Royal Institution has been arranged:—January 20th, Sir William Bragg, K.B.E., F.R.S., Fullerian Prof. of Chemistry, "Photo-electricity"; January 27th, Miss D. A. E. Garrod, author of "The Upper Palæolithic Age in Britain," "Prehistoric Cave Art;" February 3rd, Mr. E. C. C. Baly, F.R.S., Professor of Inorganic Chemistry, University of Liverpool, "Photosynthesis"; February 10th, Mr. B. Melvill Jones, Francis Mond Professor of Aeronautical Engineering, University of Cambridge, "Research on the Control of Aeroplanes"; February 17th, Rev. E. M. Walker, LL.D., Pro-Provost of Queen's College, Oxford, "The University: Its Ideals and Its Problems"; February 24th, Mr. George Gordon, Merton Professor of English Literature, University of Oxford (subject not yet announced); March 2nd, Sir Farquhar Buzzard, M.D., Regius Professor of Medicine, University of Oxford, "The Psychology of the Sick"; March 9th, Mr. Edward A. Milne, F.R.S., Beyer Professor of Applied Mathematics, University of Manchester, "The Sun's Outer Atmosphere"; March 16th, Dr. Edmund T. Whittaker, F.R.S., Professor of Mathematics, University of Edinburgh, "The Quantum and Relativity Theories of Light"; March 23rd, Dr. Ernst Cohen, For. Mem. R.S., Hon. M.R.I., Director, Van t'Hoff Laboratory, University of Utrecht, Holland (subject not yet announced); March 30th, Sir Ernest Rutherford, O.M., Pres. R.S., Professor of Natural Philosophy, R.I., and Cavendish Professor of Experimental Physics, University of Cambridge, "Radioactive Atoms and their Structure."